Learning drivers

Rural electrification regime building in Kenya and Tanzania

Robert P. Byrne

DPhil Thesis

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I hereby declare that this thesis has not been and will not be submitted in whole or in part to another University for the award of any other degree.

Signature……………………………….

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UNIVERSITY OF SUSSEX

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Abstract

Rural electrification has been a long-standing objective in many developing countries. For decades, the assumption and practice has been to build centralised generating capacity and transmit the electricity over national grids. More recently, interest has grown in using PV (photovoltaic) technology as a solution to the problem of rural electrification. A private household market for PV has been developing in Kenya since 1984 and now has more than 200,000 systems installed, sold through this private market. Consequently, it is widely hailed as a success story among developing countries. Until recently, Tanzania had almost no household PV market, despite interest from a number of actors, including some of those who have been involved in enabling the rapid growth of the market in Kenya. However, sales of PV began to grow quite rapidly from the early 2000s and the trend appears to be gaining pace, with an estimated 285 kWp sold in 2007, having risen by 57% in one year. At the time of the research, there were two large donor-funded PV projects underway in the country.

The research attempts to explain the dynamics of the two PV niches over the past 25 years using strategic niche management as its theoretical framework. It finds that the Kenyan niche has benefited more from donor support than is usually acknowledged. The thesis also makes theoretical and methodological contributions. It offers a way to connect first and second-order learning to expectations and visions concepts; dimensions expectations and visions; and presents a tool for systematic investigation of socio-technical trajectory developments.

The thesis also suggests a number of ways in which the strategic niche management framework could be enhanced. These include stronger theorising about learning, and the incorporation of power, politics and risk into the theory.

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Abbreviations and Acronyms

ABM	Associated Battery Manufacturers
AC	Alternating Current
ADF	African Development Foundation
AIBM	Automotive and Industrial Battery Manufacturers
AID	Agency for International Development (USAID)
APSO	Agency for Personal Service Overseas
AT	Appropriate Technology
BOS	Balance of Systems
BP	British Petroleum
CBK	Cooperative Bank of Kenya
CBS	Central Bureau of Statistics
COSTECH	Commission for Science and Technology
CPI	Consumer Price Index
CSC	Commonwealth Science Council
DC	Direct Current
DFID	Department for International Development
DIY	Do-it-yourself
DOE	US Department of Energy
EAA	Energy Alternatives Africa
EAC	East African Community
ECN	Energy research Centre of the Netherlands
EPI	Expanded Programme on Immunization
ESD	Energy for Sustainable Development
ESDA	Energy for Sustainable Development Africa
ESMAP	Energy Sector Management Assistance Programme
FEE	Free Energy Europe
FEF	Free Energy Foundation
GDP	Gross Domestic Product
GEF	Global Environment Facility
GNP	Gross National Product
GOK	Government of Kenya
GTZ	German Development Cooperation (Deutsche Gesellschaft für Technische Zusammenarbeit)
GVEP	Global Village Energy Partnership

HIVOS	Humanist Institute for Development Cooperation
IFC	International Finance Corporation
IGAD	Intergovernmental Authority on Development
ILO	International Labour Office
IMF	International Monetary Fund
ITDG	Intermediate Technology Development Group
KARADEA	Karagwe Development Association
KEBS	Kenya Bureau of Standards
KENGO	Kenya Environmental Non-Governmental Organizations
KENPREP	Kenya Photovoltaic Rural Energy Project
KEREA	Kenya Renewable Energy Association
KES	Kenya Shilling
KESTA	Kenya Solar Technician Association
K-REP	Kenya Rural Enterprise Programme
KSTF	KARADEA Solar Training Facility
KUSCCO	Kenya Union of Savings and Credit Cooperatives
LEC	Longford Engineering Company
MEM	Ministry of Energy and Minerals
MERD	Ministry of Energy and Regional Development
MESP	Micro-Enterprises Support Programme
MFI	Micro-Finance Institution
MIT	Massechusetts Institute of Technology
MOE	Ministry of Energy
MOF	Ministry of Finance
MWE	Ministry of Water and Energy
MWEM	Ministry of Water, Energy and Minerals
NAPS	Neste Advanced Power Systems
NARC	National Rainbow Coalition
NASA	North American Space Agency
NCST	National Council for Science and Technology
NGO	Non-Governmental Organisation
ODM	Orange Democratic Movement
OIPSP	Orkonerei Integrated Pastoralist Survival Programme
OPEC	Organization of Petroleum Exporting Countries
OSEP	Orkonerei Solar Energy Project

PDF	Programme Development Facility
PNU	Party of National Unity
PRA	Participatory Rural Appraisal
PV	Photovoltaic
PVGAP	Photovoltaic General Approval Program
PVMTI	Photovoltaic Market Transformation Initiative
RAAKS	Rapid Appraisal of Agricultural Knowledge Systems
RAEL	Renewable and Appropriate Energy Laboratory
RE	Renewable Energy
REA	Rural Energy Agency
ROK	Republic of Kenya
SACCO	Savings and Credit Cooperative
SAREC	Swedish Agency for Research Cooperation with Developing Countries
SELF	Solar Electric Light Fund
SHS	Solar Home System
Sida	Swedish Development Cooperation
SNM	Strategic Niche Management
STEP	Solar Technician Evaluation Project
TAKILUKI	Institute of Swahili and Foreign Languages (Taasisi ya Kiswahili na Lugha za Kigeni)
TASEA	Tanzania Solar Energy Association
TaTEDO	Tanzania Traditional Energy Development and Environment Organization
TAZARA	Tanzania Zambia Railway
TBS	Tanzania Bureau of Standards
TEDAP	Tanzania Energy Development and Access Expansion Project
TPTC	Tanzania Post and Telecommunications Corporation
TRC	Tanzania Railway Corporation
TROSS	Tropical Solar Systems
TV	Television
UJ	Umeme Jua
UK	United Kingdom
UN	United Nations
UNCNRSE	United Nations Conference on New and Renewable Sources of Energy

UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
URT	United Republic of Tanzania
US	United States
USA	United States of America
USAID	United States Agency for International Development
USD	United States Dollar
USSR	Union of Soviet Socialist Republics
UTAFITI	Tanzania National Scientific Research Council, now COSTECH
VAT	Value Added Tax
VCR	Video Cassette Recorder
VDC	Volts DC
VETA	Vocational Education and Training Authority
WHO	World Health Organization
Wp, kWp, MWp, TWp	watt-peak, kilowatt-peak, megawatt-peak, terawatt-peak

1 Introduction

Rural electrification has been a long-standing objective in many developing countries. The development benefits of electricity are assumed to be many, including "improvements in health, education, and opportunities for entrepreneurship" (Dubash 2002:2). For decades, the assumption and practice in developing countries has been to build centralised generating capacity and transmit the electricity over national grids (Goldemburg *et al*. 2000:375). However, despite years of work and large investments, only a small percentage of the populations of many developing countries has access to electricity. More recently, interest has grown in using photovoltaic (PV) technology as a solution to the problem of rural electrification. This interest is underpinned by the fact that the technology uses sunlight to generate electricity, and that PV systems are inherently modular. The use of a renewable energy, of course, can mitigate against climate change. PV's modularity is seen as attractive for at least two reasons: it makes it more amenable to use in rural areas of developing countries where power needs are generally small, particularly in households; and, with market-based approaches to development in favour, it is relatively easy to sell through retailers.

There has been a private household market for PV in Kenya since at least 1984; a market that is widely hailed as a success story among developing countries (Jacobson 2004). At present, there is estimated to be more than 200,000 solar home systems (SHSs) installed in the country, and that these were sold through the private market (Hankins 2005:8-9). According to ESD (2003:8), this amounts to about 3 MWp of installed capacity in the household market (or about 4 MWp including all applications). As a result, policymakers have been interested to use the Kenyan 'model' in order to disseminate PV elsewhere in the developing world using the private sector (Hankins 2007). A number of donor-supported projects were implemented in African countries through the 1990s but none appears to have been as successful at diffusing PV as the Kenyan market. Until recently, Tanzania had almost no household PV market despite interest from a number of actors, including some of those who have been involved in enabling the rapid growth of the market in Kenya. However, sales of PV began to grow quite rapidly from the early 2000s and the trend appears to be gaining pace, with an estimated 285 kWp sold in 2007, having risen by 57% in one year (Felten 2008a). ESD (2003:8) estimates the Tanzanian SHS installed capacity to be about 500 kWp (or about

1.3 MWp for all applications). Recent estimates of the Tanzanian PV market suggest it has reached 1 MWp of total installed capacity for SHSs and small commercial applications, and about 2.5 MWp altogether (Hankins, Saini and Kirai 2009:2). A number of large donor-supported projects are currently active in the country, but there is also a burgeoning private sector of PV companies servicing the market that was estimated to be worth USD 2 million in 2007-2008 (Sawe 2008).

Considering that PV is still an expensive technology that requires subsidies in the wealthier countries to stimulate market-growth, the question arises why are PV systems selling so rapidly in these two developing countries? Furthermore, why did a private market for household PV systems emerge in Kenya in 1984? PV systems were significantly more expensive at that time. And, if a PV market emerged in Kenya 25 years ago, why did one not emerge in Tanzania?

This research tries to answer these questions, driven by one overarching question: why are household photovoltaic systems being adopted at significantly different levels in Kenya and Tanzania?

The research uses strategic niche management (SNM) as its theoretical framework; a qualitative research methodology with an eclectic intellectual heritage. Chapter two includes an elaboration of the framework and an extended discussion of learning, something that is central to SNM but not fully theorised. Therefore, the discussion on learning is an attempt to suggest how this might be addressed. Chapter three explains the methodology used to operationalise the SNM framework.

Beginning with chapter four, we enter the empirical part of this dissertation with a broad sweep of the context for the two case studies. This includes a lengthy discussion of development thinking and its evolution since approximately the end of the Second World War, together with relevant aspects of the political economies of Kenya and Tanzania since independence. Also within chapter four, there is a series of short sections concerning the early understandings of household energy use in developing countries, following interest stimulated by the oil crises of the 1970s; debates around the same time about rural electrification; the evolution of the global PV niche since the oil crises; the UN conference held in Nairobi in 1981, which was part of an international effort to begin the transition from oil-based economies; and, finally, some discussion and analysis of the arrival of PV technology in East Africa.

Chapter five is about our first case study, the Kenyan PV market. This is sectioned into themes that begin approximately chronologically but is not simply a timeline of events. Likewise, chapter six, which covers our second case Tanzania, is sectioned into approximately chronological themes, although they are not all directly comparable to those of the Kenya chapter. In chapter seven I attempt to answer the research question, and to abstract the theoretical and methodological lessons from the cases. Finally, chapter eight provides a summary of the contributions of the dissertation, a discussion of the main conclusions, and some recommendations for further research and policy.

2 Theoretical Frameworks of Technical Change

2.1 Introduction to the chapter

This chapter sets out the theoretical framework for the dissertation. It briefly reviews a number of theoretical approaches that might be considered appropriate for analysing the evolution of the PV markets in Kenya and Tanzania, including technology transfer, innovation and diffusion/adoption systems, and learning-based approaches to project implementation. The discussion argues that these are less adequate approaches for analysing the Kenyan and Tanzanian PV markets than socio-technical theories. It then attempts to explain some of the foundational concepts used in socio-technical theorising about technology adoption, before discussing strategic niche management in particular. An important aspect of this thesis is that it suggests SNM under-theorises learning, and so the chapter discusses some ideas for addressing this challenge. Another, related, aspect of this concerns expectations and visions; important dimensions of the SNM framework. The discussion makes use of recent insights from the expectations literature and, in light of the discussion on learning, suggests a way in which first and second-order learning, and expectations and visions, could be reconciled to achieve more clarity.

2.2 Review of some technical-change literatures

Before turning to a detailed discussion of socio-technical theories and strategic niche management, we consider a number of theoretical approaches that have evolved either specifically for analysing technical change in developing countries or have been applied in these contexts. These are broadly categorised as ‘technology transfer’, ‘innovation systems’, ‘diffusion-adoption systems’ and ‘learning-based approaches’. Each could merit extensive discussion. Indeed, I read each of these literatures in depth, as part of the research activities, but they are only briefly addressed here. While this treatment is inevitably crude – neglecting many of the subtleties of each of the approaches – it is sufficient to convey the basic argument that none is as appropriate as SNM to this dissertation for analysing the historical dynamics and evolution of the emerging household PV markets in Kenya and Tanzania. By dynamics, we mean the interdependent changes over time of a number of dimensions of a complex system such as a market.

2.2.1 Technology transfer

One of the more obvious places to begin a discussion on theories to analyse the dynamics of the adoption of PV in Kenya and Tanzania is in the technology transfer literature. There is no space here to examine fully such a vast body of work but we can make use of several reviews of the literature. Judging by these reviews, it is clear that the overriding concern of the technology transfer literature is with the accumulation of technological capabilities within developing-country firms. From this focus, the literature discusses how capabilities are built (Reddy and Zhao 1990; Bell and Pavitt 1993), the role and modes of technology transfer in this process (Bell and Pavitt 1993; Correa 1994; Radošević 1999), the relationship between technological capabilities and industrialisation (Lall 1992; Cimoli, Dosi and Stiglitz 2009), and how industrialisation through the accumulation of technological capabilities can be enhanced (Bell 1990; Radošević 1999; Cimoli *et al*. 2009). There is little in these discussions that is concerned with the dynamics of household-level demand; indeed, there is little concern with dynamics in general (Bell 2006). Further critique stems from the lack of attention to contextual factors and other forces, despite attempts by some to address political economy interests (see, for example, Bastos and Cooper 1995; Cimoli *et al*. 2009), leading to calls for theory and research on technological capability-building to incorporate broader factors (e.g. Bell 2009).

None of this is without relevance to the analysis of the continuing experiences in Kenya and Tanzania. The what, how, when and why of building technological capabilities in firms in these countries are important considerations in painting a full picture, but they are only part of the picture. Household consumers rarely feature in these discussions and yet they play an important role in final demand, the significance of which is clear in the case of Kenya and increasingly so in Tanzania. The technology transfer literature, therefore, provides insufficient breadth for analysing the dynamics of household PV markets in two different contexts.

2.2.2 Innovation and diffusion/adoption systems

Innovation systems theory makes more of linkages with users of technology. These are seen as important for developing successful innovations and for functioning *systems* of innovation (see for example Lundvall, 1988; Metcalfe, 1997). However, the focus remains on firms and inter-firm linkages (producer-firms and user-firms); little is said about household-level users of technology.

Likewise, the diffusion/adoption literature makes some reference to customers but they are analysed in terms of whether they will adopt a product or not, formalised, for example, with the use of probit models (Freeman and Soete 1997:354):

> The central assumption underlying the probit model is that an individual consumer … will be found to own the new product … at a time when their income … exceeds some critical level. This critical or tolerance income … level represents the actual tastes of the consumer … which can be related to any number of personal or economic characteristics. Over time, though, with the increase in income and assuming an unchanged income distribution, the critical income will fall with an across-the-board change in taste in favour of the new product, due both to imitation, more and better information, bandwagon effects, etc.

This hints at broader social processes and factors ("imitation", "bandwagon effects") that could be important explanatory variables in diffusion/adoption processes. Indeed, interest has grown in developing more systemic approaches – inspired by theories of self-organisation – that could integrate broader social phenomena into theories of technical change. Despite this, the literature seems pre-occupied with modelling theories of the firm (albeit progressively more sophisticated and systemic), with the result that consumers, social processes, and so on, are 'exogenised' to the system's environment (see, for example, Silverberg 1988; Metcalfe 1988). Where technology-purchase decisions are analysed in more qualitative terms they are done so with regard to particular psychological characteristics of adopters and especially in terms of their 'innovativeness' (see, for example, Rogers 1983 and subsequent editions). This neglects the technical characteristics of products (Barnett 1990) and does not allow us to analyse why those particular products are the ones being 'diffused' or 'adopted'; that is, we cannot explain why particular technological configurations exist rather than others. Once again, this literature does not provide us with tools to analyse the dynamics of user-demand and technical change interactions or to incorporate broader contextual factors and forces. If we do want to analyse such interactions then the co-evolution that this suggests implies we need to look for theoretical frameworks that enable us to study learning, a process that occurs in different settings and at different scales.

2.2.3 Theories of learning in development projects

This brings us to theories of project implementation in developing countries that focus more explicitly on learning. A number of such theories emerged, beginning in the 1980s, in efforts to replace 'blueprint' approaches to development with projects that would evolve more organically by paying attention to *process* (Romijn, Raven and de Visser 2010). While these 'learning-based' approaches are explicitly concerned with the co-evolution of user-needs and solutions, they are primarily focused on community-level interventions and how they can be better managed so as to foster learning. Korten (1980), for example, discusses an approach that is largely about community-project management rather than the dynamics of technology diffusion-adoption and innovation processes, as is the discussion in Bond and Hulme (1999). Clearly, project management is an important element in the introduction of new technologies – whether community-based or otherwise – but provides us with little help if we need to consider learning that may be occurring across many projects in different contexts, especially if they are being implemented by different actors. Furthermore, a number of processes may be more open-ended than projects, as well as contingent or *ad hoc*. And, as we have observed with the other theories discussed so far, context remains largely an exogenous factor (Romijn *et al*. 2010). One further critique, from the perspective of our needs here, is that an intensely micro-focus on project implementation is unlikely to help us analyse *sectoral* emergence and growth, such as may be the case with PV in Kenya and Tanzania.

Closer to our needs here is a model developed by Douthwaite, Beaulieu, Lundy and Peters (2009), which the authors call learning-to-innovate (LTI). The model is focused on agricultural projects and how they can help farmers to adopt and adapt innovations of two different kinds: artefacts and strategies, whether radical or incremental. It is based on Rogers (2003) but adds a function – learning and selecting – that feeds back into four of Rogers' five stages of adoption. The LTI model is more systemic than the learning-based approaches discussed above and attempts to situate itself in context. However, the recognition of context does not appear to be operational in the theory, even at the conceptual level. Moreover, it assumes the existence of some kind of appropriate innovation system. Where there may be the emergence of some kind of 'innovation system' such as in a new domain or around a new (to the context) technology, the use of the LTI approach could miss important evolutionary processes. That is, we could expect in a new domain (or with a new technology) that there will be *ad hoc* measures and activities, implemented by disparate actors and in highly uncoordinated ways. Some interventions may be well coordinated and involve networks of different kinds of actors but it would be a liberal interpretation to refer to these as innovation systems.

The intention of the foregoing discussions is not to portray the various ideas, concepts and theories as irrelevant; rather, it is to say that they are valuable in particular ways but are insufficient for our purposes. My contention is that we need broader – more comprehensive – theories to understand phenomena such as the diffusion/adoption of PV systems in Kenya and Tanzania, and that socio-technical[1] ideas being developed in the 'transitions' literature offer this potential. The next section outlines these ideas in general before discussing the strategic niche management approach in detail.

2.3 Socio-technical systems

With its intellectual roots in evolutionary economics, and using "insights from historical, sociological and actor-network studies" (Raven 2005:25-27), the socio-technical approach understands a technology to be more than a discrete artefact. The artefact is perhaps the most visible part of a 'technology' but it is embedded within a complex social, economic and technical system. Definitions vary to some extent, but this system is conceptualised as a technological regime, described by Hoogma, Kemp, Schot and Truffer (2002:19), as:

> … the whole complex of scientific knowledge, engineering practices, production process technologies, product characteristics, skills and procedures, established user needs, regulatory requirements, institutions and infrastructures.

This notion implies path dependency, in that current knowledge, practice, and so on, depend on what has gone before; and technological trajectory, in that current knowledge, practice, and so on, guide but do not determine what will happen in the future (Nelson and Winter 1982:262-263; Dosi 1988:225; Dosi and Nelson 1993:30).

[1] 'Socio-technical' is meant to include a wide range of dimensions: social, cultural, institutional, technical, economic, etc.

Of course, the regime is able to exist because it serves some societal need[2], such as electricity supply[3], in a way that is acceptable and/or convenient to that society. In other words, there is an important interdependent relationship between a 'technology' and the wider social context such that each can effect change in the other. Some regimes can change completely: they are organised around radically different technological artefacts with different bases of scientific knowledge, institutions, and so on, but servicing familiar needs. Some are completely new regimes: previously unknown possibilities are realised, such as the development of passenger air travel. It is these socio-technical transformations that are the focus of the transitions literature: analytically, how and why they happen; and normatively, how they can be controlled or guided.

Recent developments in the literature have resulted in a framework for organising the complex relationships in socio-technical systems (see Figure 2.1). Socio-technical regimes are conceptualised at a meso-level, with a landscape at the macro-level and niches at the micro-level, to form a multi-level perspective (Geels 2002).

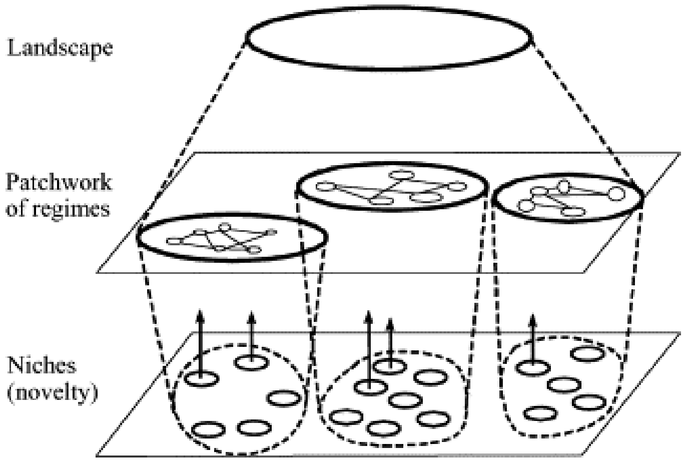

Figure 2.1: The multi-level perspective
Source: Geels (2002:1261)

The landscape refers to a heterogeneous set of factors such as economic growth, war, cultural norms, etc.; and socio-technical niches refer to 'proto-regimes' where novel technologies are the focus of experimentation and learning (Geels 2002:1259-1261).

[2] The use of the word 'need' here is not meant to imply some fundamental human need, although that may be a reasonable interpretation for some socio-technical regimes. Rather, it refers to the whole range of wants, needs and demands within the relevant social context.
[3] In fact, the socio-technical view would consider supply and demand together as a co-construction or co-evolution (Geels 2004:898).

Transitions are then defined as "changes from one sociotechnical regime to another" (Geels and Schot 2007:399). A key feature of a socio-technical regime is that trajectories from different domains – policy, science, technology, culture, users and markets – are aligned; they are mutually reinforcing (see Figure 2.2) so that "to understand dynamics in [socio-technical] systems we should look at the co-evolution of multiple trajectories" (Geels 2004:911-912, following Freeman and Louça 2001).

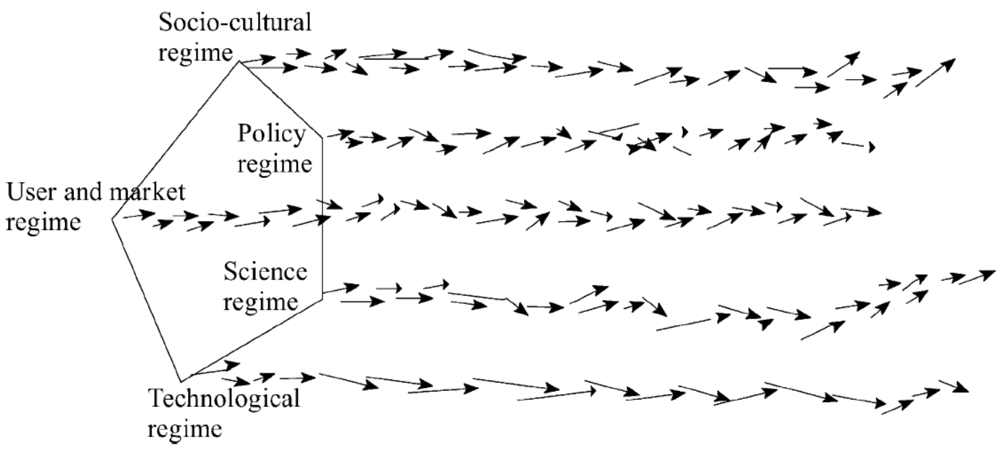

Figure 2.2: Alignment of regime trajectories
Source: Geels (2004:912)

Building on this heuristic framework, the transitions literature has begun to recognise in recent years that not all transformations from one dominant socio-technical configuration to a new one take place in the same way. For example, Berkhout, Smith and Stirling (2004) propose a typology of transition *contexts*, and Geels and Schot (2007) propose a taxonomy of transition *pathways*. The Berkhout *et al*. typology represents regime adaptive capacity: a regime's ability to reproduce itself in response to selection pressures. The Geels and Schot taxonomy results from interactions of niche, regime and landscape; and the timing of niche innovations.

All these ideas are potentially useful for enhancing our understanding of large-scale or long-run technical change but they have been developed in the context of highly industrialised economies. It is not at all clear that these ideas translate easily into the context of the particularly undeveloped economies such as those of Kenya and

Tanzania. The landscape and niche constructs are relatively straightforward to apply (at least superficially) but the regime concept is much more problematic, especially in the case of rural electrification. This is not to say that regimes could not be identified, in some form, but it is to say that such identification remains an empirical challenge. Until that challenge is met, neither the Berkhout *et al*. typology nor the Geels and Schot taxonomy can be applied directly to the case studies in this research.

However, some of the underlying processes and drivers of change articulated in these concepts might well be discernible in the Kenyan and Tanzanian contexts. If this is the case, we can approach the problem by considering both countries to be in the process of rural electrification regime building. Even if one, or both, of the countries already has an identifiable regime, this approach can still be fruitful because we can assume there would have been a process of regime building in the past. Therefore, if we begin from the assumption that the PV sectors in both countries are socio-technical niches then we can apply the strategic niche management approach, which is closely related to the transition concepts discussed above, as a way to analyse the dynamics of the Kenyan and Tanzanian PV markets.

2.4 Strategic Niche Management

Strategic niche management is a framework that can be applied either analytically or normatively (Raven 2005:37). In its normative mode, it is intended to be used for finding and developing sustainable solutions to societal needs. Central to the approach is the creation of experiments with promising technologies in social contexts in order to generate opportunities for co-evolutionary learning. However, as promising technologies are often unready to face real-world selection pressures, their experimental application in social contexts requires some form of protection (Schot, Hoogma and Elzen 1994; Kemp, Schot and Hoogma 1998; Raven 2005; Schot and Geels 2007; Smith and Raven 2010). This 'protection' is the essence of the niche concept: the niche is a real-world space in which 'normal' selection pressures are suspended, weakened or changed in order to enable the survival of the promising technology so that actors can learn about its desirability and develop it further (Kemp *et al*. 1998). Selection pressures can be changed in a number of ways: for example, through the use of public subsidies to bring costs in line with those of incumbent technologies; R&D budgets can be used to support real-world trials or demonstration systems, where there is no requirement for any direct commercial return; or new regulations can be introduced to favour the promising technology over the incumbent (Schot *et al*. 1994; Schot and Geels 2007). Implicit in the notion of 'promising technology' is an expectation or belief by actors that the technology will eventually be socially and commercially viable, and so they are willing to protect it and invest effort to develop it (van Lente 1993; Raven 2005; Schot and Geels 2007). The hope, or objective, is that the effort to develop the technology (and adjust the system in which it is embedded) will indeed lead to a socially and commercially viable innovation such that the protection can be removed and a new socio-technical regime will emerge based around the innovation (Schot *et al*. 1994; Kemp *et al*. 1998; Raven 2005). Proponents of SNM suggest that a niche innovation is more likely to become an element of a new socio-technical regime when niche experiments are rich in 'second-order' learning and carried by broad networks of actors, including users (Hoogma *et al*. 2002:194). In contrast to 'first-order' learning, which is concerned with the functioning of a technology (important though that is), second-order learning arises "when conceptions about technology, user demands, and regulations are … questioned and explored" (*ibid*.:29). In other words, second-order learning occurs when assumptions and behaviour patterns are examined in conjunction with the use of particular technologies. A broad network of actors is important for generating lessons about product integration, admissibility and acceptance, which are processes that Deuten, Rip and Jelsma (1997:132) describe as "societal embedding".

But this discussion is concerned with SNM in its normative mode: that is, where SNM is used explicitly as a method for finding and developing sustainable solutions to societal needs. In this mode, a niche – a protective space – would be *created* by implementing various measures to change selection pressures, and experiments in social contexts would be designed to stimulate first and second-order learning. After some time, the protection would be removed and there would be a hope of wider spread adoption of the niche innovation. While this approach may have been used as a policy tool in some cases, many of the examples of the introduction of promising technologies have not been based on the purposive use of SNM. In these cases, if we wish to learn something about the introduction and development of new (sustainable) technologies, we can use SNM analytically. We then need to empirically *identify* the various categories and concepts of SNM in operation: a protective space or niche; experiments (see section 3.3.5); relevant actor-networks; expectations or beliefs about promising technologies; first and second-order learning; the enabling and constraining institutional environment, including social norms, professional practices and formal institutions; and the context in which the innovation is situated. All these interact dynamically over time and so we need to trace them and their interactions historically. SNM, therefore, focuses our attention on the niche of the MLP and a set of dimensions that links with Geels' (2004:912) multiple trajectories. So, in its analytical mode, SNM directs us to examine (1) the processes and quality of learning, and (2) the composition and quality of social networks, as they relate to technological experiments in a social context.

Recently, SNM has begun to incorporate further elaboration and refinement of the notions of expectations or beliefs about promising technologies, although work on the concepts of expectations and visions is already long-standing (see for example: van Lente 1993 and 2000; Michael 2000; and a special edition of *Technology Analysis and Strategic Management*[4], particularly Geels and Raven 2006). Expectations and visions are understood to play an important role in the development of a technology; in the innovation process itself, and in the wider context. According to Raven (2005:39):

> … expectations about the future provide the legitimacy for actors to invest time and effort into a new technology that does not yet have any market value. In the beginning, the expectations may be broad and fragmented. Actors may have different visions of the future and different expectations about the viability of a technology. Some actors may opt for one technological trajectory, while others opt for a different one.

Implied in this account are requirements for learning (broad and fragmented expectations may need to be sharpened and combined into a more coherent whole), for alignment (actors with different expectations and visions may be diverted by contestation, competing for the same scarce resources), and for some degree of structuring (actors opting for different trajectories may not benefit from shared learning, scale economies, and so on). So, there are clear links with the socio-technical view of SNM, and the implication that the various elements of the theory are interdependent.

[4] See: *Technology Analysis & Strategic Management*, Volume 18, Numbers 3/4, July – September 2006.

We will discuss the conceptual elements of SNM – learning, expectations, and societal embedding[5] – more fully in the next sub-sections, in terms of how they are articulated in the SNM literature. However, one of the contentions of this thesis is that learning, as conceptualised in SNM, is somewhat under-theorised; the learning aspect – central to the framework – could be significantly enhanced if anchored more strongly and explicitly in learning theory. Therefore, while the next three sub-sections elaborate SNM's understanding of the elements in its conceptual framework, an additional discussion that explores some learning theory is given in section 2.5.

2.4.1 Learning

As mentioned in the preceding section, SNM conceptualises two types of learning that are important for us to analyse when investigating niche processes: first and second-order learning. This section gives an elaboration on these concepts, as SNM posits them.

First-order learning

Hoogma *et al*. define first-order learning as the testing of a technological artefact, or technical configuration of artefacts. The motivation here is to understand how to make that *particular* artefact or configuration work, rather than explore alternatives. In other words, an experiment begins with a prospective technological solution rather than the intention to investigate a problem. Consequently, users are not challenged to question or explore their needs, there are few opportunities to open up or discover novel approaches, and so there is little opportunity for co-evolutionary learning to occur. Many valuable lessons can be generated by first-order learning but they will be concerned with "how to improve the design, which features of the design are acceptable for users, and about ways of creating a set of policy incentives which accommodate adoption" (Hoogma *et al*. 2002:28).

Second-order learning

Second-order learning is understood to contrast with first-order learning because it is about investigating the assumptions around a particular societal function. By doing so,

[5] I am using the short hand 'societal embedding' here to incorporate the notion of institutionalising practices of various kinds (from the formal to the informal, or non-formal) and the social networks necessary for the development and diffusion of learning, expectations, and these institutions.

SNM posits that “co-evolutionary dynamics” will arise whereby there will be “mutual articulation and interaction of technological choices, demand and possible regulatory options” (Hoogma *et al*. 2002:29). In other words, second-order learning is thought to be fundamental learning about the function itself within its social context, not simply a kind of instrumental learning about a particular technological solution.

Articulating learning

Learning in itself, whether first or second-order, is not enough to have an impact on behaviour. It must be articulated and disseminated if the lessons are to provide useful information with which to make adjustments to behaviour (Raven 2005:42, following Ayas 1996:39). Raven elaborates this further, explaining five ‘methods’ of learning that may be ineffective, as Ayas identifies them. These are: role-constrained (an actor’s role prevents further action); superstitious (inadequate reasoning or basis for changed behaviour); situational (uncodified learning); fragmented (learning is not disseminated); and opportunistic learning (actors learn something useful but lose influence). So, if it is to be useful, the implications are that learning should be interpreted with an understanding of who is generating the lessons; the evidential basis for the lessons; and it needs to be codified and disseminated.

Comments on SNM and learning

While SNM’s understanding of learning is potentially useful in its provision of two basic classifications – first and second-order – it is less helpful in explaining what these really mean. That is, two categories of learning provide for parsimony in applying the theory, but their definitions are quite vague and we are unsure of their provenance in terms of any learning literature. There are occasional references to single and double-loop learning, notions coming from the organisational learning literature but also from the social learning literature (see for example: Argyris 1976; Keen, Brown and Dyball 2005), but little explanation beyond these being instrumental (first-order, single-loop) and assumption-testing (second-order, double-loop). It is not clear that these two bodies of work are actually based on the same or consistent learning theories. As a result, we are left to analyse learning in a somewhat *ad hoc* way, deciding at the time if the learning we are examining is first or second-order, but without any coherent basis for making the decision. Moreover, for SNM in its normative mode, a robust understanding of learning would help us to design more effective experiments to generate lessons and make further use of them.

Consequently, as mentioned in the preceding section, this thesis argues that we need to strengthen this aspect of SNM. In order to further this aim, some learning theory is explored more deeply in section 2.5 below, following the elaboration of the other conceptual elements of the SNM framework.

2.4.2 Expectations and visions

Although we mentioned expectations and visions in section 2.4 when discussing SNM in broad terms, we did not specify how they are conceptualised. Recent work in the literature has attempted to develop these ideas, including effort to bring precision to their definitions. As a result, it is apparent that there is a range of understandings of the meaning of expectations and visions. Perhaps two of the clearest definitions attempted are those by Berkhout (2006) and Eames, McDowall, Hodson and Marvin (2006). The first of these, given by Berkhout (2006:302), proposes a definition of visions as:

> …collectively held and communicable schemata that represent future objectives and express the means by which these objectives will be realised.

While Eames *et al*. (2006:361-362) suggest that:

> … visions … refer to internally coherent pictures of alternative future worlds. Normative in character, visions are explicitly intended to guide long-term action. … expectations … refer to less formalised, often fragmented and partial, beliefs about the future.

So, expectations and visions are conceived to be cognitive representations of a technological future, which either guide action or articulate what action is required in the realisation of that future. Furthermore, as Berkhout implies, we can distinguish between *individual* and *collective* expectations and visions. In general, collective expectations are those that are of interest to the analyst because individual visions are "not likely to be socially significant, even [when] held by a powerful social actor" (Berkhout 2006:301). Geels and Raven are less explicit in this sense but they imply similar interest when they talk of *shared* routines and their effect on local actors' practices; the significance being that when "technical search activities in different locations are focused in a similar direction, they add up to a technical trajectory" (Geels and Raven 2006:375). The implication of this is clear when considering the role of expectations in socio-technical niche development processes: a socio-technical trajectory may lead to the emergence of a new socio-technical regime.

Perhaps the most fundamental function of expectations is already expressed in their definitions. As van Lente (2000:43) says:

> …one of the striking things about technological futures is that they often appear in the imperative mode. That is, once defined as promise, action is required.

This is supported by Michael (2000) when he suggests that the way in which expectations and visions are expressed does rhetorical work: the articulation of a particular technological future is not neutral. In Berkhout's (2006:300) terms, visions are "encoded or decoded as either utopias or dystopias"; they are "moralised" in order to enrol actors because the benefits and dis-benefits of particular futures will be unevenly distributed. Of course, to identify a strategy is not to explain the enrolment of others. As Konrad (2006:432) notes:

> …the analytical focus on the coupling of interests and expectations does not explain why others should accept these promises, especially if they have no strategic interest in the technology in question.

Konrad's point is to caution against a unidirectional understanding of expectation dynamics. Certainly, the rhetorical force of visions of the future is important but these visions emerge from *interactive* processes; through public and specialist discourses, and innovation activities. As such, Berkhout (2006:301-302) argues that:

> …it may be more productive to see expectations as 'bids' about what the future might be like, that are offered by agents in the context of other expectation bids. Expectations offer a potentiality that in most circumstances requires the endorsement and affiliation of other actors before it can be actualised.

Drawing from this discussion, we can say that expectations are, in essence, motivators of action in a particular socio-technical direction. That is, they operate as targets towards which actors can align themselves and their activities. Visions are more detailed; they specify the means to achieve the target. But, different actors create different targets and so there is always a process of negotiating the particular contents of expectations when, as is necessary, the effort is made to recruit resources. Always at stake, of course, is the uneven distribution of benefits and dis-benefits that any realised expectation or vision would bring, and whether this would mean a change from the present (uneven) distribution. In other words, the process of creating collective expectations and visions is inherently political: it involves strategic interest, power and authority; persuasion, negotiation and conflict.

There is a clear implication in this discussion that expectations and visions are intimately related to learning (Raven 2005:43). What is perhaps less clear is the nature of this interrelatedness. We would assume, of course, that expectations and visions, as cognitive schemata, can be changed through learning; and we can assume that the subject of learning will be influenced by the content of expectations and visions (indeed, we have defined them partially in this way – as guides for activity). But, we now have concepts for first and second-order learning (if ill-defined), and for expectations and visions. The difficulty here is that, although SNM recognises that these concepts interact in operation, there is little theory to guide our understanding of the nature of these interactions. We will return to this in the fuller discussion of learning in section 2.5, where a possible way forward will be suggested.

2.4.3 Societal embedding

The purpose of our interest in analysing the development of a socio-technical niche is to examine the extent to which it can become a regime. The processes of societal embedding, therefore, are important indicators. If a technology is not becoming embedded in a society then we need to understand what is preventing it from happening. SNM suggests that social networks are essential for societal embedding, but we can also identify two other aspects that facilitate the process: the development of institutions and the diffusion of these to structure niche practices.

Social networks

Niche experiments involve actors who interact through networks; what we could call carrying networks. SNM posits that the composition of these networks is important for access to resources and for the opportunities created or constraints imposed by the diversity or otherwise of network participants (Raven 2005:39-41). A narrow network is one that is dominated by regime 'insiders' who are, it is assumed, more likely to maintain the *status quo*, or favour only incremental innovations, than support radical solutions to a function's needs. A broad network, by contrast, would include regime 'outsiders', users and non-users[6] (Hoogma *et al*. 2002:192,194). However, it is not enough for a broad range of actors to be connected; the quality of their interactions is important. That is, the network members should be *active* participants in the innovation process (Raven 2005:40).

Actors may be attracted to a network through the deployment of expectations. However, this does not mean that their expectations are necessarily well-aligned with others in the network; there may still be work to do in aligning expectations (Raven 2005:40-41). The point of this is to establish the shared rules, and so on, that Geels and Raven (2006) identify as important for setting and consolidating socio-technical trajectories. Moreover, the alignment of actors in this way helps to build a constituency of support around a particular solution (Kemp *et al*. 1998:186), and stabilise actor relations (Hoogma *et al*. 2002:29). Finally, apart from this network alignment, the work of actors needs to be directed at network integration: that is, the forming of ties to other networks, such as those of suppliers of complementary technologies and strategic elements of the regime (Deuten *et al*. 1997:132; Weber, Hoogma, Lane and Schot 1999:18).

Institutions and structuring

Another aspect of societal embedding relates to institutions, interpreted in a broad sense. Following Hodgson (2006), we define institutions to include: laws, regulations and policies; technical practices and procedures; and norms, conventions and cultural practices. We have already mentioned integration in the discussion on networks, and there are characteristics of this that include institutions: for example, "existing practices and cultural repertoires of users" (Deuten *et al*. 1997:132). But we could add to this, following Deuten *et al*., two other aspects – admissibility and acceptance. Both these aspects relate to institutions as we have defined them above: admissibility is about compliance with laws and regulations (some of which may be inappropriate or unavailable for a new technology); while acceptance refers to the perceptions of users and non-users (there may be resistance to a new technology).

[6] Non-users may be those who would be affected by a technology even though they are not directly participating in its use, an example being householders near a wind farm (Raven 2005:40).

Cosmopolitan actors

The process of embedding these institutions is what we might call structuring, or institutionalisation. Clearly, networks are important for this process as they facilitate the diffusion of institutions (such as best-practice, heuristics, and so on) that are developed or adapted through the learning generated in experiments. This helps to structure socio-technical niches and can be further enhanced by the actions of what Deuten (2003) calls cosmopolitan actors. These are actors who work at a level ‘above’ individual experiments – the cosmopolitan level – and help to spread the lessons from particular experiments to other locations and other experiments.

According to Deuten (2003), all technological knowledge begins in a local context and so work must be done to spread that knowledge if it is going to contribute toward the emergence of a new technological regime. For this to happen, the knowledge must be made ‘translocal’: that is, it must be de-contextualised so that it is available for application by others in new contexts. In turn, application in new contexts creates new knowledge that also must be de-contextualised for further ‘transfer’. Cosmopolitan actors co-ordinate these transfers and, in doing so, increasingly structure local practices: that is, they institutionalise practice. This is not to say that local practices first emerge from a vacuum: there are institutions already in place and these influence practice; but these institutions are adjusted, changed, and new ones created, in response to practice.

2.5 Reflections on some learning theory

This section attempts to introduce some ideas from the learning literature, particularly cognitive psychology. The discussion is necessarily brief and so cannot hope to cover the broad and diverse range of theories available in the literatures on the psychology and philosophy of learning and knowledge. Instead, it offers a flavour of one theory in particular – Kolb’s experiential learning – and supplements this with notions from some other theorists. The intention, however, is not to prescribe a particular theory with which to enhance SNM. Rather, the purpose is to attempt to demonstrate that SNM could be strengthened by making more explicit use of these literatures – as some theorists, particularly with regard to expectations, have already begun to do. Part of the attempt here is to suggest a way in which to achieve greater clarity around the notions of first and second-order learning, and their relationship to expectations and visions. This suggested approach is then used in the case studies reported in chapters five and six.

2.5.1 Experiential learning

From cognitive psychology, Kolb's (1984) experiential learning theory attempts to describe the psychological processes by which an individual creates symbolic representations of the world as well as those by which that individual uses symbolic representations to create action in the world. His working definition of learning is that it is a "process whereby knowledge is created through the transformation of experience" and this is extended to include the creation of meaning (Kolb 1984:38, 52). Under this definition, there are two parts to the process of learning: the grasping of experience and the transformation of that grasped experience. Both parts are needed for learning to occur (Kolb 1984:42):

> The simple perception of experience is not sufficient for learning; something must be done with it. Similarly, transformation alone cannot represent learning, for there must be something to be transformed, some state or experience that is being acted upon.

Each of the two elements – grasping and transforming – can be achieved in either outward (active or concrete) or inward (reflective or abstract) oriented modes. The grasping of experience can be done via apprehension (outward) or comprehension (inward); transforming can be done via extension (outward) or intention (inward) (see Figure 2.3). Concentrating on the apprehension-comprehension "dialectic", Kolb arrives at a "dual-knowledge theory" (Kolb 1984:100-105); the two types of knowledge being personal and social.

Knowing by apprehension relies "on the tangible, felt qualities of immediate experience"; knowing by comprehension relies "on conceptual interpretation and symbolic representation" (Kolb 1984:41). There is a correspondence here with Polanyi's (1958, cited in Kolb 1984:103) description of knowledge types: articulate and tacit knowledge. In Kolb's view, Polanyi's "articulate form" is "comprehension-based knowledge" while the tacit form is apprehension-based. Furthermore, these forms of knowledge are transformed (extensionally or intentionally) by appreciation, in the case of tacit knowledge, and by criticism, in the case of articulate knowledge (Kolb 1984:103).

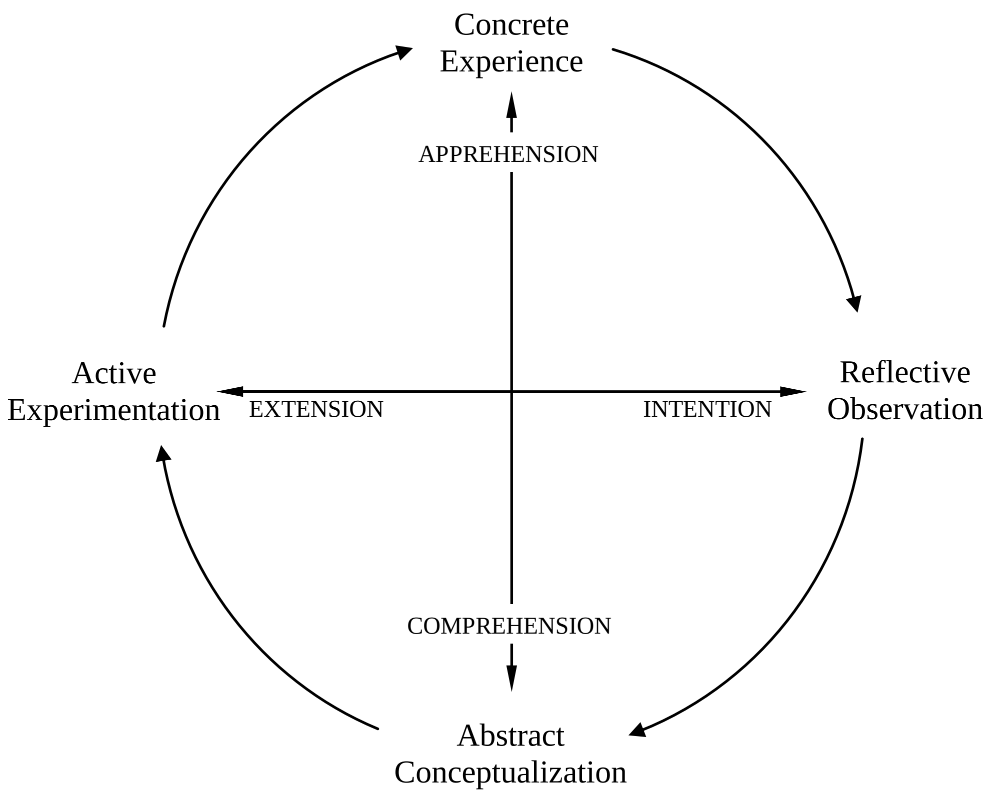

Figure 2.3: Kolb's simplified learning cycle: grasping and transformation processes
Source: Kolb (1984:42)

Following from these ideas, Kolb defines personal and social knowledge. Personal knowledge is "the combination of … direct apprehensions of experience and the socially acquired comprehensions [used] to explain this experience and guide … actions"; and social knowledge is "the independent, socially and culturally transmitted network of words, symbols, and images that is based solely on comprehension" (Kolb 1984:105). However, according to Kolb, social knowledge does not "exist independently of the knower"; it is only knowledge when it is embodied, or personal. This is in line with Polanyi and Prosch (1975, particularly 22-45; Polanyi 1966) who insist that all knowledge is personal: knowledge is embodied; it extends to include the senses – the mind *and* body (Tsoukas 2002:4). As such, we can observe its effect – or its expression – especially in performance. But knowledge *itself* has a tacit quality; a dimension that is deeply personal and inarticulable. When knowledge is disembodied it is abstracted; it loses this tacit quality and becomes something else, akin perhaps to information. Another actor can use this information – apply it through practice – and begin to cultivate its meaning, to embody it once again for themselves and so develop their own personal knowledge.

2.5.2 First and second-order learning, expectations and visions

Further to Kolb's definition of personal knowledge, we can say something about expectations. The definition again:

> … the combination of … direct apprehensions of experience and the socially acquired comprehensions [used] to explain this experience and guide … actions

This bears some similarity to Popper's (1979:66) definition of what he calls subjective knowledge, which he says "consists of dispositions and expectations". This is perhaps made clearer when Popper (1979:21, italics in original) discusses the person of "practical action":

> … a man of practical action has always to *choose* between some more or less definite alternatives, since *even inaction is a kind of action*.
>
> But every action presupposes a set of expectations; that is, of theories about the world.

So, we have here references to what we could interpret as SNM's expectations and visions. That is, expectations and visions could be understood to be theories about the world: they define what *could* be in the future and so, in this sense, can *only* be theories. Indeed, this is closely aligned with the understanding expressed by Geels and Raven (2006:375), following Dosi (1982), Nelson and Winter (1982) and Bijker (1995), when they refer to expectations and visions as:

> … a special set of cognitive rules that are oriented to the future and related to action, in the sense that they give direction to search and development activities

Insofar as the notion of Kolb describing personal knowledge as a *guide* to action, it may be better to argue that this guide is a set of assumptions – more or less articulated – rather than necessarily detailed prescriptions of what to do (such as theories might be). Remembering the expectation-vision distinctions introduced by Berkhout (2006) and Eames *et al*. (2006), and our understanding of expectations as targets, we could equate this set of assumptions with SNM's *expectations*. By logical extension, we could then equate the more detailed "theories about the world" (Popper 1979:21) with *visions*. Now, on the basis that second-order learning is about testing assumptions, we could say that second-order learning results in a change of expectations. And, by logical extension again, we could say that visions, which Berkhout (2006) suggests contain the means to achieve objectives, are detailed through first-order learning.

If there is a change of expectations then there is a change of direction, figuratively speaking, to search activities (Geels and Raven 2006). This implies, therefore, that second-order learning results in a change of socio-technical trajectory. The learning that then follows can be considered first-order: that is, the search activities in a particular direction result in first-order learning, which detail visions; first-order learning envisions expectations, which have been created through second-order learning.

2.5.3 Speculations based on learning theory

Cosmopolitan actors are conceived as those who de-contextualise knowledge for its transfer to other locations. If we accept the ideas of Kolb, and Polanyi and Prosch, then the 'knowledge' that these actors 'transfer' is not really knowledge at all, because it is disembodied and represented in symbolic form. Instead, we could call it knowledge-representation or an expression of knowledge: that is, a vehicle to convey information from one actor to another; someone who can understand the symbols and therefore find meaning in them. In this sense, knowledge *transfer* becomes knowledge *translation*. And, in keeping with our interest in *collective* expectations, for example, we could redefine Kolb's *social* knowledge as collective[7] knowledge-representation, or collective expressions of knowledge. Finally, there is one further qualification regarding the use of the word 'knowledge'. Considering that we are interested in the learning that many different types of actors experience in everyday life, as well as the more specialised technical kinds of learning, the concept of 'knowledge' here is a liberal one[8]. It is meant to include belief – whether 'true' or 'false', however we choose to define these terms – as well as attitudes, and so on; various concepts that could be regarded as types of cognitions.

[7] One reason for not using the qualifier 'social' is that it is used in a number of places in the literature – such as in social learning – that are different to the notion here. Therefore, this is an attempt to avoid confusion with these other uses.

[8] I am grateful to Justine Johnstone for comments on the notion of knowledge and other aspects of this discussion. Any faults are entirely my own responsibility.

From this brief discussion, we can begin to say something about processes of learning and how the knowledge created can be expressed to facilitate its translation. This is important because we need to be able to explain the structuring processes involved in socio-technical niche development and, as we have seen in the discussion of SNM theory, learning and knowledge *transfer* are considered central to these processes.

Expressions of knowledge

So, the first step is in expressing knowledge. This is relatively unproblematic when we consider much of the technical learning that might take place. We can assume that this is easily represented in such forms as mathematical notations and engineering formulas. Of course, there could be other kinds of technical learning that are not so easy to codify in this way, but the use of a mathematical example is merely to convey an ideal-typical notion for the purposes of discussion. The particular way in which the mathematical representation is formed will have been agreed through normal technical procedures such as detailed discussions in standards bodies, in technical forums of other kinds such as journals, and so on. We could say that this type of knowledge expression is *codified* and has been *established* through *agreement*. Once established, it is relatively *rigid*: that is, there would have to be considerable work to reach agreement before it could be changed. This rigidity facilitates its communication. That is, it can be explained to others who have enough technical knowledge to understand it – or to decode it – and there can be confidence that it will not change quickly, so there is no risk in training others to use it, to move it from one location to another, and so on.

A simple example could be measuring the voltage of a battery. There is some skill involved in actually measuring battery voltage and using the proper tools, and there is some knowledge that is needed to understand what the value of the measurement means: is the battery fully charged, or is it discharged? There is a procedure for doing this in a way that avoids ‘mis-measurement’: if a battery has been on charge then it should be disconnected from the charger for at least 20 minutes to allow its voltage to stabilise before a measurement can be taken. This is clearly a procedure that has been agreed and established as good practice. It can be explained easily to someone with some knowledge of batteries, and the information derived from the measurement can, in SNM terms, be classified unproblematically as generated through first-order learning.

If we consider the other extreme of a notional knowledge continuum – deeply tacit knowledge – then its expression is difficult or even impossible to codify. However, Tsoukas (2002:16) argues that tacit knowledge is "displayed, manifested, in what we do". We can observe the 'performance' of others and the outcomes of these performances[9]. Bandura (1986:47), in explaining his social cognitive theory, states that observation is an important mode of learning; that we can form rules through observing others and this can help us short-cut our learning (of course, we can infer the 'wrong' rules or the performance we observe can be misleading, and so on, but we nevertheless learn *something* from the observation). The point of Tsoukas' argument is that we can begin to infer something from the performance; it enables us to discuss, to examine, and to reflect on the knowledge embodied in the performer. Communication of the knowledge expression here is particularly difficult. We are relying on *inference* and *intuition*, and so may only be able to describe the performance with metaphors (for example), or to *imitate* and *demonstrate* to others. Clearly, this would be a *fluid* kind of knowledge expression: our 'understanding' of it is unlikely to be fixed; it is likely to be open to new inferences and intuition on each performance.

As an example, we could consider the case of Kenyan PV retailers. We might say that one retailer has found a way to increase sales of PV modules by displaying an idealised picture of an installation that shows an ordinary family enjoying the benefits of PV-supplied electricity in their home. The picture will include clues as to the ordinariness of the family as well as to the functionality of a PV system. So, the house in the picture will be modest, the family will look 'Kenyan', and there will be lights, a television, and other devices in operation clearly connected to a PV module. From this, we could infer that the retailer has personal knowledge of what many Kenyans might want to know about ways to get access to electricity, and is expressing this knowledge in the performance of creating the image. The image, once created, is a 'frozen' expression of that knowledge. The retailer's knowledge could include the understanding that many Kenyans do not know anything about the functionality of PV (hence the electrical

[9] I am using 'performance' in a very general way here. For example, the use of any skills can be considered performance.

appliances in the picture); that PV is perceived to be only for the rich (hence the ‘ordinary’ Kenyans); that PV is seen as unsuitable for use in a household (hence the modest domestic setting); that PV is seen as only for lights (hence the television); and so on.

If other retailers are able to observe the behaviour of the successful retailer (the displayed image and increasing sales) then they may decide to imitate, according to the extent to which they understand the first retailer’s behaviour and perceive it to be related to that success. In turn, they may have to go through something of their own learning and refining (the image may just bring more customers to the shop, but there could be other tacit qualities in the seller’s performance that need cultivating if the potential customers are to become purchasers). The point is that their learning process *could* have been shortened by the opportunity to copy from someone else. So, the image becomes a collectivising device; it expresses personal knowledge in a form that communicates something about that knowledge, albeit one that is open to misunderstanding.

Between these two ‘extremes’, we could posit further gradations. Moving from the most tacit to the most codified, we could have more *explicit* knowledge-expressions. Explicit here would mean imprecisely but linguistically formulated concepts, and assumptions; those that are highly contestable and rely heavily on *interpretation* or *inference*. They would be *flexible*, requiring considerable *discussion* and *description* for their communication. Consequently, the translation of such expressions would be difficult. The learning process may be one of observing, trying, risking, and so on.

Moving closer to the codified end, we could have much better *articulated* expressions of knowledge. These would also be linguistically formulated but more coherent, detailed, and so on, than the explicit form. There would still be room for *interpretation* but the concepts may be more *established*, perhaps substantiated with evidence. As a result, they may be more *stable* than the explicit expression but not as rigid as the codified form. They could be communicated through *explanation* and *discussion*, but the basic ideas may be reasonably well known. Consequently, their translation may be relatively straightforward compared with the more deeply tacit expressions, but not unproblematic compared with those that are codified. The learning process may be readily directed because the concepts are well defined: that is, it may be straightforward to formulate *questions* to be *investigated*. And, finally, there is a sense about this learning process that is suggestive of it being first-order.

From this rather sketchy discussion we could summarise the ideas, and these are given in Table 2.1. It should be stressed, however, that this is a highly tentative arrangement. First, the theorising of learning at the beginning of this section is far from complete, and neglects many of the subtleties of the theories mentioned. Second, the intention here was to *suggest* that SNM could benefit from a strengthening of its learning concepts, and to demonstrate one example of how this could be done. Third, in doing so, the learning theories reviewed are only a small part of the highly diverse learning literature. And, finally, we have not identified second-order learning here but, the logic of the scheme given in the table suggests that this could be associated with the manifest and explicit forms of expression, as we have used them in this discussion.

Table 2.1: Knowledge expressions and elaborations

Knowledge expression	Example	Communication	Learning
Codified (agreed, established)	Mathematical propositions (rigid)	Instruction, explanation	*First-order* Measuring, testing, verifying
Articulate (established, interpreted)	Linguistic formulations (stable)	Explanation, discussion	*First-order* Investigating, questioning, analysing
Explicit (interpreted, inferred)	Linguistic formulations (flexible)	Discussion, description	*Second-order?* Observing, trying, risking
Manifest (inferred, intuited)	Performance (fluid)	Description, demonstration	*Second-order?* Observing, experiencing

Summary of SNM implications

In terms of the strategic niche management view of learning and its outcomes, first-order learning could be associated with articulate linguistic formulations of stable concepts (objects, properties, relations), and codified knowledge. Second-order learning *could* be associated with explicit linguistic formulations of more flexible concepts and assumptions, and inferred tacit knowledge. For example, stable concepts may concern technical performance such as module efficiency, relatively unproblematic in linguistic definition, calculated according to articulated rules using codified mathematical propositions. Second-order learning may concern flexible concepts such as user-practice or user-needs. These could be open to considerable interpretation and debate but are certainly explicable in some senses, for example ‘typical’ electricity consumption habits; while the meaning of electricity access for users may be very difficult to articulate other than by inference from observed practice or anecdotal evidence mediated, for example, through retailers.

Particularly in communicating explicit and manifest forms of knowledge-expression, it would be important to consider a diversity of views. This is based on the premise that different actors have different assumptions and knowledge. No single actor is therefore able to articulate precisely on behalf of all other actors and so we have a requirement for negotiation and discussion if we are to generate knowledge that reflects many experiences. This feeds into the notion in SNM that a broad network of actors should be involved in niche experiments, and that there should be a range of experiments. This way, many different views and experiences are incorporated[10] in many different combinations. It is much easier to identify assumptions – to articulate assumptions – when contrasting outcomes can be analysed. This then helps to see how assumptions influence and change outcomes, as well as articulating new ways to frame problems.

2.6 Summary of the chapter

This chapter reviewed a number of theoretical approaches to understanding the diffusion and adoption of technologies in developing countries. It argued that none of these is sufficient for analysing the evolution of the household PV markets in Kenya and Tanzania, and suggested that socio-technical theories of transition may be more

[10] Of course, this diversity could also be a source of contention, leading to political behaviour, and so on.

appropriate. As such, the chapter introduced some of the foundational concepts of socio-technical theorising of long-run technical change, followed by a particular focus on strategic niche management – the theoretical framework used for this dissertation. The discussion argued that SNM under-theorises learning despite this being of central importance to the SNM approach. It then outlined one learning theory from the cognitive psychology literature with a view to suggesting how this issue could be addressed. The outcome was inconclusive but it did find a way of rationalising the linkages between first and second-order learning, and expectations and visions. That rationalisation is employed in the remainder of this dissertation. The next chapter outlines the methodology used for the thesis, including a discussion of how the SNM concepts are operationalised.

3 Research Design and SNM in Operation

3.1 Introduction to the chapter

The last chapter presented a discussion of the theoretical basis for this dissertation. This chapter outlines the design of the research and how the key concepts we will use have been operationalised for the context of Kenya and Tanzania. There is then a section describing the methods used for data collection, followed by a brief description of the process used for analysing the material. The chapter finishes with some observations regarding the limitations of the methodology.

3.2 Research design

This section describes the basic research design. Included here is a reiteration of the main research question and the sub-questions that emerge from the choice of SNM as the research tool. Following this, the research strategy is discussed; a strategy that is formed around the notion of socio-technical trajectories, a notion that is elaborated in the section following this.

3.2.1 Research questions

The main question motivating this research is:

> Why are household photovoltaic systems being adopted at significantly different levels in Kenya and Tanzania?

From the theoretical perspective of strategic niche management, we should seek part of the explanation in the niche-internal dynamics; that is, the interactions and institutionalisation of expectations, learning, and actor-networks. The other important part of the explanation should be found in the relationships between these niche-internal developments and the broader context, again, in terms of dynamics. This theoretical position, together with the recognition that PV has been present in East Africa for around 25 to 30 years, suggests a set of more specific sub-questions:

1. What have been the important dynamics in expectations, learning, actor-networks, and institutions over the past 25 to 30 years in the household PV-system socio-technical niches in Kenya and Tanzania?

2. What have been the interactions between these niche-internal dynamics?
3. What have been the broader dynamics over this period and, perhaps, before?
4. What have been the interactions between these broader dynamics and those in the PV niches of Kenya and Tanzania?

3.2.2 Research strategy

The research employed a comparative historical case-study approach that was predominantly qualitative but made use of descriptive quantitative data. The choice of the case-study approach was driven by the concern within the theoretical framework for process – implying a temporal dimension and, therefore, historical; and comparative because we were hoping to gain insights into the explanatory power of SNM itself, as well as the generalisability of the approaches used for technology diffusion. As such, information-rich data were needed in order to engage in an analysis that could be termed 'process-tracing' (Gerring 2007; George and Bennet 2004).

In order to identify significant processes to trace, the basic strategy of the research built on the Geels and Raven (2006) approach in which changes in technological trajectory provide the sites for deeper investigation (see the discussion below for more on how trajectories are defined in this dissertation). The justification for the strategy is related to an assumption about the influence of expectations, and other cognitive content, on socio-technical trajectories. Geels and Raven (2006:376, italics in original) express the logic of the argument as follows:

> If we accept that shared cognitive rules and expectations create stable trajectories, then a change in *direction*, i.e. non-linearity, depends on a change in the *content* of cognitive rules and expectations.

In other words, if we detect that there has been a change in trajectory then there is likely to have been a period preceding the change that is of interest to us for analysis; that expectations and visions, learning, and so on, have changed in some important ways and influenced socio-technical development. But, this research stretched the idea to include *attempted* changes in trajectory, in an effort to achieve symmetry in the explanation: 'failed' trajectories need to be explained in the same terms as 'successful' ones (Bijker 1995; Geels and Raven 2006:379-380).

Using this approach, a basic timeline of the evolution of the PV socio-technical niches in Kenya and Tanzania was constructed. From this timeline, it was possible to identify events, processes and other developments that appeared to bear a significant relationship to niche-trajectory changes, thereby suggesting the sites for focused investigation. In addition to the niche-internal processes, these deeper investigations included attention to the dynamics in the broader environment; where these broader dynamics were suggested by the findings of Jacobson's (2004:123-124; 2005:11-14) research into the growth of the Kenyan PV market:

- the connections between Western donors (their prevailing development aid paradigms), and Kenya and Tanzania;
- the countries' demographic structures and income distributions, including sources of income and consequent spending power;
- PV equipment supply-side developments;
- rural electrification debates, investments, and developments on the ground;
- developments of services that require electricity supply in order to gain access, such as the expansion of the television broadcasting network;
- national economic and business environments.

The notion of a socio-technical trajectory includes a range of 'fronts' where socio-technical work is done in the evolution of the overall trajectory. Therefore, the identification of sites for investigation attempted to ensure that all these fronts were represented in the 'sample' that was researched and analysed. This will become clearer in the discussions below on operationalising the theoretical framework, and the choice of interviewees.

3.3 Operationalising the theoretical framework

We begin here with a fuller discussion of the notion of a socio-technical trajectory, as it is used in this dissertation. The notion is an important underlying idea for the rest of the SNM framework, including its relation to concepts beyond its primary focus on niches; for example, the idea of a socio-technical regime. Moreover, it provides the basis on which we will trace much of the evolution of expectations and visions, and the other dimensions of SNM, in the empirical chapters to follow. With the socio-technical trajectory notion elaborated we will discuss briefly SNM's key theoretical constructs: expectations, visions, institutions and institutionalisation, and learning and knowledge. The discussion of operationalising the framework then turns to an elaboration of the notion of experiments and other ways in which learning can be fostered. The section then discusses how we have identified niches in this dissertation and finishes with observations on the difficulties of identifying socio-technical regimes in the context of developing countries.

3.3.1 Socio-technical trajectories

The notion of a technological trajectory is closely bound to the concept of technology itself. In Sahal's (1981:22) view, "technology is as technology does", a functional or, in Sahal's terms, systems view. From this perspective, Sahal suggests that it is possible to measure technical change by observing, for example, changes in power-to-weight ratios, thermal efficiency, and so on, and to do so in some objective sense. Dosi (1982) has a similar view but defines two levels: technological paradigm and technological trajectory. Concerning the technological trajectory, Dosi (1982:152) writes:

> We will define a technological trajectory as the pattern of "normal" problem solving activity (i.e. of "progress") on the ground of a technological paradigm.

And, in regard to the notion of a technological paradigm, Dosi (1982:153)writes:

> The identification of a technological paradigm relates to generic tasks to which it is applied (e.g. amplifying and switching electrical signals), to the material technology it selects (e.g. semiconductors and more specifically silicon), to the physical/chemical properties it exploits (e.g. the "transistor effect" and "field effect" of semiconductor materials), to the technological and economic dimensions and trade-offs it focusses upon (e.g. density of the circuits, speed, noise-immunity, dispersion, frequency range, unit costs, etc.). Once given these technological and economic dimensions, it is also possible to obtain, broadly speaking, an idea of "progress" as the improvement of the trade-offs related to those dimensions.

Using these ideas, we could say that PV systems constitute a technological paradigm. The tasks are to generate and store electricity; the material technologies selected consist of silicon-based semiconductors, lead-acid based energy storage, electrically-powered luminaires, and so on; the properties exploited include the photo-effect, the galvanic effect, and so on; and the technological and economic trade-offs include photovoltaic cell efficiency, battery charge and discharge characteristics, and so on, versus production costs. A particular pattern of problem-solving activity within this paradigm would then define a particular technological trajectory. For example, the problems of cell efficiency and production costs have led to the development of amorphous-silicon cells: they have much lower cell efficiency than mono or polycrystalline cells but are much cheaper to manufacture as they require a lower-grade silicon and are more amenable to continuous production techniques (ICCEPT and E4tech 2003). Hence, we could characterise an amorphous-module PV-system trajectory, alongside others such as a monocrystalline-module PV-system trajectory.

But, we are interested in *socio*-technical trajectories. Therefore, we need to expand our definition to include relevant social dimensions. While we are interested to analyse socio-technical *niches* in this dissertation, we are assuming that a niche trajectory is in important ways a nascent regime trajectory. This brings us back to the Hoogma *et al*. (2002;19) definition of a socio-technical regime:

> … the whole complex of scientific knowledge, engineering practices, production process technologies, product characteristics, skills and procedures, established user needs, regulatory requirements, institutions and infrastructures.

So, in general, a socio-technical trajectory (whether niche or regime) is a particular pattern of these elements and the focus of problem-solving activities within the pattern. Strictly speaking, innovations in any of these elements (incremental or radical) would constitute a new trajectory. However, there must be room within this view to make a case for whether a change in an element really constitutes a change in trajectory or not.

We can represent this notion of a socio-technical trajectory schematically, in order to give us a clearer view of what is involved (see Figure 3.1). And we will use this diagram, in conjunction with our concepts for expectations and visions, as a way to explain the way first and second-order learning are operationalised in this dissertation.

It is not claimed that the elaboration here is a complete description of a socio-technical trajectory. The diagram given in Figure 3.1 may be either too simple *or* too complex. The point is to convey the notion of the various ‘fronts’ on which socio-technical work could be done as a technology and associated practices evolve. There is also room for further discussion within the idea. For example, ‘user needs’ are further divided into preferences, practices and requirements. We might reasonably argue that user practices are institutions and so should be classified under that grouping. Indeed, this dissertation operationalises institutions in this way (see below). Still, if we collect together the lowest level elements given in the tree diagram in Figure 3.1 (i.e. those elements to the right of the diagram), we have a list of the potential dimensions along which we could analyse, systematically, socio-technical trajectory changes (see Figure 3.2). And, in principle, we could use these to map the complete evolution of socio-technical trajectories.

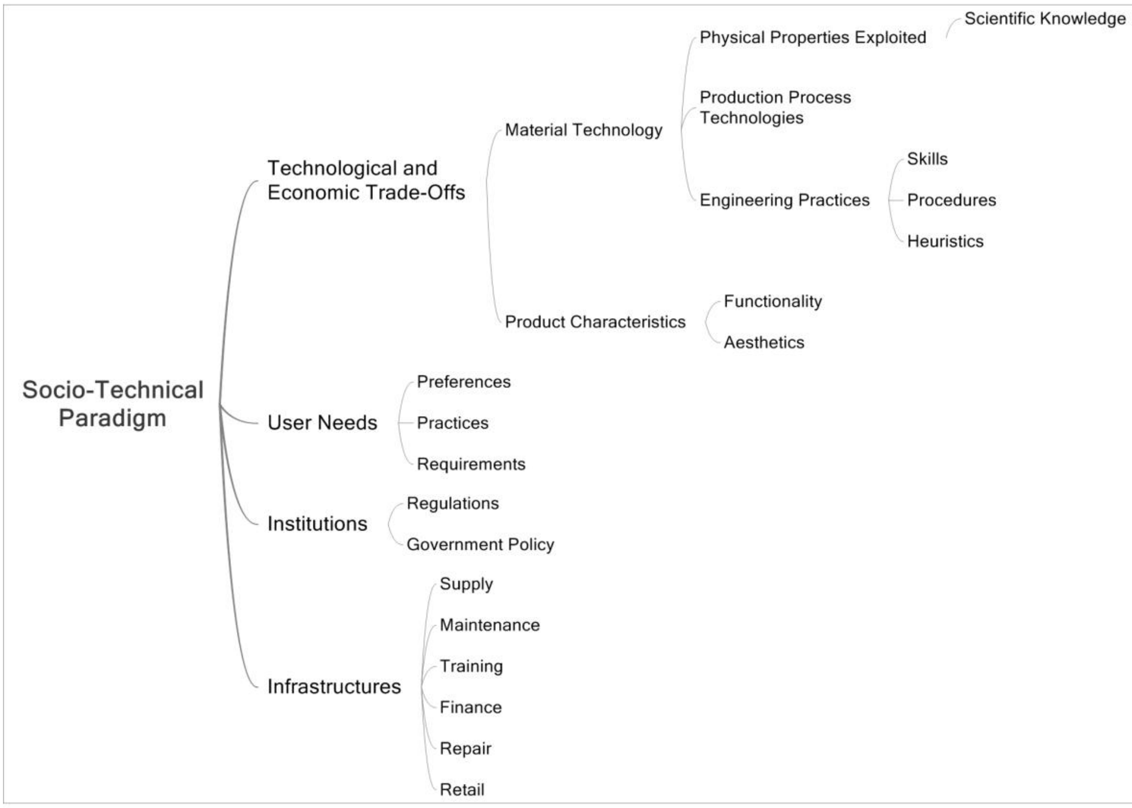

Figure 3.1: A socio-technical trajectory and its dimensions, based on Dosi (1982) and Hoogma *et al*. (2002)

Regarding how we recognise changes in trajectory, we can use our theorising of expectations, visions, and first and second-order learning, from chapter 2 (section 2.4.2). There, we argued that second-order learning leads to a change of expectations, and this we equated with a change of direction of the trajectory; and first-order learning envisions expectations giving ‘movement’ along that trajectory dimension. This is shown schematically in Figure 3.3 below.

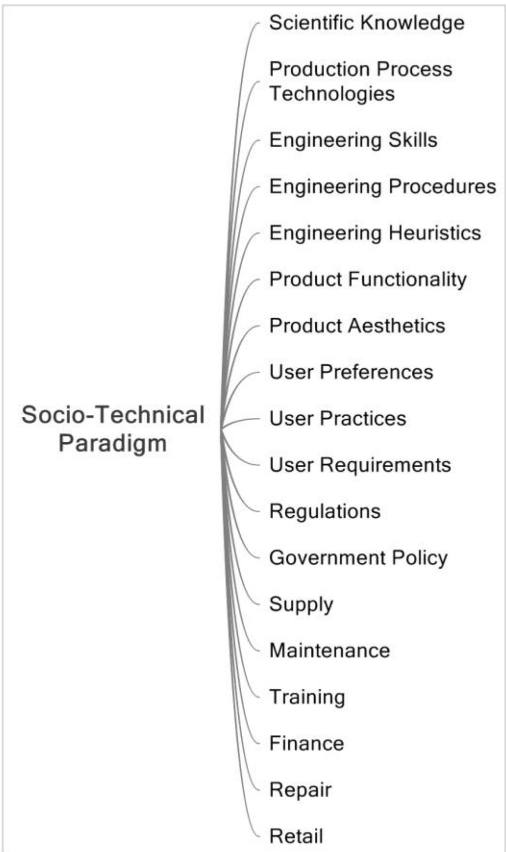

Figure 3.2: The dimensions of a socio-technical trajectory

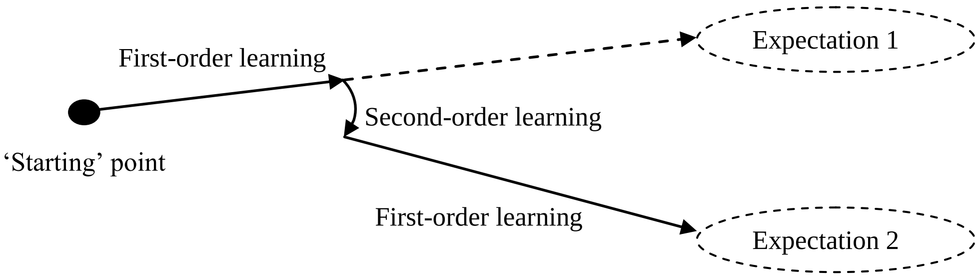

Figure 3.3: Schematic representation of first and second-order learning, and expectations and visions, whereby first-order learning details the vision

So, we may initially be on a trajectory along which we are envisioning 'Expectation 1' through first-order learning. At some point, we experience second-order learning and this stimulates a new expectation – 'Expectation 2' – that now acts as the guide for the direction of learning, rather than our initial expectation. This is not to say that the first expectation will have been dropped. It is quite possible that others will continue to pursue it, while the alternative expectation is the focus of parallel learning effort.

3.3.2 Expectations and visions

Because expectations and visions are about a future state of affairs, their expression will tend to be normative and couched in rhetorical terms, particularly so for expectations as we have defined them in chapter 2. Immediately, this guides us in identifying expectations in operation. In line with Berkhout's (2006:301-302) notion that expectations could be considered "bids", we can consider them to be in operation in argument; in discussions that are intended to persuade. We will refer to the process whereby individuals adopt an expectation (or vision) as collectivisation. Visions provide detail of the means to achieve expectations, again, following Berkhout (2006). However, we will also include a more passive form of visions; they can be descriptive of what is a current situation, as much as a description of the means to achieve a new situation.

3.3.3 Institutions and institutionalisation

Following Hodgson (2006:18), we will consider institutions from a broad view: "systems of established and embedded social rules that structure social interactions". So, we include the whole range of structuring 'rules' from the formal to the informal; from laws and regulations to cultural practices and social norms. We will also consider practices that emerge from users' interactions with technologies as institutions: for example, as we will see in the empirical chapters, the practices associated with using lead acid batteries to get electrical services in the home. Altogether then, we will consider the following as forms of institutions:

- Policies (government, local and international organisations, company)
- Laws (local and international)
- Regulations (local and international)
- Practices (technical, cultural and social)
- Conventions (local, international and cultural)
- Norms (local, international and cultural)

The process of institutionalisation is taken to mean the societal embedding of these various forms of institutions. There could be different institutionalising methods, such as formal training or more informal habituation – “the psychological mechanism by which individuals acquire dispositions to engage in previously adopted or acquired (rule-like) [behaviour]” (Hodgson 2006:18).

3.3.4 Learning and knowledge

Learning is defined here as a “process whereby knowledge is created through the transformation of experience” (Kolb 1984:38). Learning, in general, is recognised by changed behaviour and expressions of knowledge. As we have discussed elsewhere, the relationship between first and second-order learning, and expectations and visions, is more specific in this dissertation. First-order learning refers to the ‘filling-in’ of detail; the instrumental particularities of a chosen ‘direction’ that is guided by an expectation. Second-order learning is recognised by a change in that direction.

3.3.5 Experiments and other sites of learning

SNM is concerned with experimentation in a social context where learning can take place. An obvious form that such experimentation takes is in projects. Projects are often implemented as a way to discover more about whether a technology offers a practical solution to a problem and so can be considered experiments in the SNM sense. In the Kenyan and Tanzanian contexts, many projects are funded and managed by donors, although sometimes in partnership with other kinds of actors (e.g., local, private and public sector) and sometimes with local resource contributions. Many of these projects are centred on the use of technology but not all. Some are concerned with adapting technologies to the local context, and some are concerned with developing local capacity to manufacture or assemble technologies.

However, there are other kinds of projects that could be characterised as experiments in a broader sense. These may be concerned with gathering information; a process that is guided by question-asking and motivated by a need to increase knowledge about a social phenomenon or system. One example is a market survey: this might attempt to discover the needs of users; describe the state of the supply side of a market; identify the constraints on market growth; and so on.

Yet other kinds of projects can also be sites for learning, or offer opportunities to identify whether (and what) learning has taken place. An example here would be the writing of policy. While writing a policy document may not usually be understood as a project, it certainly shares similar characteristics. It is normally time-bound, has specific objectives, and requires the targeted deployment of resources (financial, political, knowledge, etc.) in order to be achieved. Furthermore, there is a process during which a number of actors contribute to the formulation of the policy document: through background papers, in discussions, or directives from those with power. It would be difficult to see such work as experimentation, although a consultation process prior to writing policy could be seen as an experiment – it would be seeking answers to questions and generating new information. Whether the process is one of formulating a policy document or consulting, we can recognise there is potential to reveal details of learning that could be of use to our analysis. And, extending this argument, we can consider other processes (e.g., those that are unfunded, without specific objectives) and events (e.g., workshops, conferences) as sites of learning that may provide us with useful information for analysis.

3.3.6 Socio-technical household PV niches

In chapter 2 we stated that the essence of a socio-technical niche is that it is a 'real-world' protective space in which actors can experiment with, and develop, an innovation. While this provides us with an understanding of the niche in functional terms, it does not specify how we identify the niche operationally. For this, we begin with the societal need, which we could define as household electrical services. The particular technology of interest is PV and so we can refine our definition of the niche to household PV electrical services. But we need to add to this the actors involved and the practices associated with such services, whether they are amongst users or suppliers. Furthermore, we are interested in the whole range of institutions that might enable or constrain such household electrical services. And, of course, PV modules are connected in systems that include batteries, control technologies and loads. Taken together, then, the niche or protective space can be identified empirically as the set of actors, technologies and institutions associated with the provision of household electrical services using PV. We can also draw a distinction between a niche and a market. A PV market need not be concerned with the provision of household electrical services, except in the sense that these might motivate demand for the product. But demand for PV modules could also derive from other sources such as the need for water pumping for industrial scale irrigation. This application is far removed from household electrical services and so would be of no concern to the niche for household PV electrical services. We can, therefore, talk of niche development as something distinct from market development.

SNM states that the niche protects a novel technology from normal selection pressures. Smith and Raven (2010) argue that the notion of 'protection' is yet to be clearly understood in SNM, as is 'protective space' itself. Working inductively from the literature, Smith and Raven identify six kinds of protection available to actors (an example is given in parenthesis): economic (subsidies), institutional (favourable regulation), socio-cognitive (a research agenda), cultural (sympathetic social values), geographic (appropriate natural resource abundance) and political (a policy goal). Notwithstanding the effort of Smith and Raven to explore carefully the notion of protection, the lack of clarity in the literature makes it is difficult to be more specific about protection here. Instead, we can accept that protection is something we can identify empirically and offer insights that may arise in the course of our analysis as contributions to to a research agenda on protection and protective space.

3.3.7 Socio-technical regimes

Notwithstanding the issue of definitional ambiguity already discussed in chapter 2, the identification of a socio-technical regime is a particularly difficult challenge in the context of Kenya and Tanzania. Our primary interest is around rural electrification and so we are bound to search for what we could describe as rural electrification regimes if, indeed, they exist at all in these countries. When we try to make this search we come up against a difficulty. It is clear that both Kenya and Tanzania, and development agencies that work with them, have been operating for many years on the assumption that electrification (both rural and urban) will be achieved using centralised generation and grids for distribution. Consequently, policy making and the associated formal rule making in government (regulations and laws), as well as related activities around finance and technical practices, have all been aligned with this vision of electrification.

In these terms, we might confidently recognise the hallmarks of a socio-technical regime. Indeed, we could strengthen this view by including users. It is generally accepted that those in rural areas would think of this model of electrification if they were asked to explain what rural electrification means; indeed, they usually wish for connection to the grid. So, in an important set of ways, we would interpret this configuration of expectations and visions as constituting a socio-technical regime, because it structures peoples' practices and strategies.

However, we also know that, in practice, the grid extends services to a small fraction of the population of either country, and a very small fraction of those in rural areas. So, the low level of material infrastructure suggests something closer to a socio-technical *niche*. Furthermore, the actual sources of electrical services for many people are batteries; a small number of these are charged using PV systems but many are simply dry cell batteries bought and discarded as needed, and when they can be afforded. There is a substantial *indirect* use of the grid, through lead-acid batteries that are used in the home and taken for charging at battery charging stations. But not all battery charging stations are connected to the grid; some of them use PV systems and others use fuel-based generators. And, it is not clear to what extent this battery charging practice is 'substantial'.

So, we will take a cautious view in operationalising the concept of a rural electrification (or even, simply, electrification) regime in the contexts of Kenya and Tanzania. What we *can* identify are the agents, processes and instruments of government, and the interactions with these processes of international development actors. We can define this as the electrification *policy* regime. This is not entirely satisfactory but it allows us to indicate the main actors and to give some meaningful shape to the notion of a regime in Kenya and Tanzania. Perhaps the main actor with whom the PV niche interacts is the respective ministry: the Ministry of Energy in Kenya, and the Ministry of Energy and Minerals in Tanzania. Behind these faces of the electrification policy regime, of course, are other actors such as the ministries of finance and planning, the respective parliaments, and so on. But, also, there are important development regime actors such as the World Bank, various UN agencies, and a number of bilateral donors.

Other regimes are important in the experiences of our case countries and here we may have more success at identifying them. One could be called the finance regime. This includes the central national bank of each country that sets the institutional environment for banking and lending, the finance ministry in each country, the banks and their branches, and the micro-finance organisations that have proliferated in both countries in recent years. These are generally referred to as SACCOs (Savings and Credit Cooperatives); subject to operational and lending laws and rules set by the centre. Moreover, the number of users of these financial services is large and growing. The use of the regime notion here seems plausible.

Likewise, there is something we could discern as an education regime in both countries. We could discuss whether each is well-enough resourced, the quality of the education, and so on, but each does have an infrastructure of primary and secondary schools, vocational colleges, and universities. There are also many private schools, religious schools, and so on. There are laws and regulations in place for education, professional bodies, a ministry, education policy, and user expectations and desires to get access to education. Once again, the notion of a regime is plausible here.

3.4 Research methods, data collection and analysis

This section describes and discusses the practical efforts to conduct the research in the field, in particular, and the methods of data collection and analysis. With this in mind, there are some brief observations concerning the limitations of the methodology together with a discussion of attempts to minimise them.

3.4.1 Host organisations, dates, language and resources

The research regulations for Kenya and Tanzania require that the researcher be hosted by a locally recognised organisation. In Kenya, I was hosted by Energy for Sustainable Development Africa (ESDA) in Nairobi and, in Tanzania, I was hosted by Tanzania Traditional Energy Development and Environment Organization (TaTEDO) in Dar es Salaam. The fieldwork was conducted over the period of one year, from July 2007 to July 2008. Early in the fieldwork period, although I was already quite conversant in Swahili, I attended a two-week refresher course at TAKILUKI in Zanzibar. Resources for the fieldwork were provided by the UK ESRC as part of a 1+3 studentship.

3.4.2 Ethical considerations and confidentiality

The nature of the research topic is such that it is not particularly sensitive, in itself. However, energy has been, at times, a contentious issue and those active in PV in the two countries are generally familiar with each other. Consequently, interview respondents were given the opportunity to remain anonymous if they so wished. In the event, two respondents did wish this to be so, and their names do not appear anywhere in this dissertation. Indeed, I have had no need to cite their testimony directly, although their comments have provided some background understanding of some of the relationships and issues involved in the energy field in East Africa. Other than these considerations, general ethical codes of practice were observed willingly and without any difficulty.

3.4.3 Choice of events, processes and developments

As discussed above in section 3.2.2, the research strategy involved the identification of apparently significant events, processes and developments as entry points for deeper investigation. In practice, of course, not all those identified could be investigated. First, there were many potential candidates and so it was not possible to investigate them all; second, interviewees could not always be identified or secured; and, third, some of the developments have been thoroughly researched, or there is a great deal of secondary material with which to work, making interviews generally redundant or of lower value. The final selection of events, and so on, that were investigated is summarised in Table 3.1. The table also shows the number of contributing testimonies by sector and topic. These are not all individual interviews; some interviewees gave substantive contributions about more than one topic and so these are counted in the table.

3.4.4 Identification of interviewees, interviews and protocol

Interviewees were identified through a combination of means. First, I had some contacts already from my previous work in Tanzania. In addition to these, I made use of the snowball technique from interviewees and contacts, and performed internet searches, inspected participant lists from workshops and seminars, and identified authors of reports. A total of 206 potential interviewees were identified and 49 actually interviewed. All but one of the interviews was recorded, coming to a total of about 90 hours of interview testimony. A list of interviewees is given in Appendix B, not including the two interviewees who wished to remain completely anonymous. Not all the interviewees have been cited in the text; those that have been cited appear in the references section.

The interviews were semi-structured, based on questions developed through a process of piloting. The first few interviews were analysed to determine if the questions were eliciting answers that could be interpreted through the SNM framework. Following this, a set of generic questions was developed to be used with any interviewee, regardless of the topic being investigated. The generic questionnaire is given in Appendix A. The questions were then tailored to the topic of interest by inserting the appropriate words for the event or process of interest. For example, assuming the topic was 'Market Entry', question 1 would be written:

Generic form:

> Please describe the process in general terms: how, when, why, and by whom, was it initiated; and how did it progress through to completion?

Market Entry:

> Please describe the process of the company entering the PV market in general terms: how, when, why, and by whom, was it initiated; and how did it progress through to the present day?

However, the first question often elicited new and unexpected information and unanticipated lines of enquiry were often followed as a result. The point of the questions was to guide the interview rather than constrain it. Nevertheless, the basic format of before-during-after, further reflections, and the SNM categories, was maintained as far as possible and within the constraints of time. As can be seen at the beginning of the questionnaire, interviewees were asked if they were happy for the interview to be recorded and the manner in which they were happy to be cited. Most respondents took a copy of the recording. All interviews except one were conducted face to face, the exception being conducted over the telephone. Some interviewees were interviewed more than once and over two or three meetings, especially where they had extensive experience in a multiple of roles.

Table 3.1: Summary of interview topics and numbers of substantive contributions (KE: Kenya; TZ: Tanzania)

Development	Donor	Finance	Government	NGO	Private	University	Total
General				5	9	3	17
UN Conference 1981	1					1	2
Early Period (KE)					5		5
Solar Shamba					1		1
Three-schools					1		1
Regional Workshop	1			1	1		3
KSTF				3	1		4
Micro-Solar (KE)					2		2
MOE RE Department	1		2				3
PVMTI		1			1		2
PV Standards (KE)				1			1
KEREA				1			1
Energy Policy (KE)	1		2		1	1	5
PV Schools (KE)			2				2
PV Curriculum (KE)					1		1
KESTA				1			1
Micro-Finance		3					3
MEM RE Department			2				2
Early Period (TZ)				1	1		2
PV Cell Research (TZ)						1	1
Ultimate Energy					2		2
OSEP				1			1
TaTEDO PV Project				2			2
TASEA				2			2
Umeme Jua					4		4
UNDP-GEF Project	2				1		3
SIDA/MEM	2				2		4
FEF				2	1		3
Market Entry (TZ)					7		7
PV Standards (TZ)	1						1
Energy Policy (TZ)			2				2
Local Assembly				1	3		4

3.4.5 Secondary sources

A number of respondents were generous enough to give copies of reports and other documents that are difficult to find in the public domain. Extensive use was made of these and other secondary material, including project proposals and reports, government documents, research and consultancy documents, and some media reports. Wherever possible, if a document is available in the public domain, I have tried to refer to that version rather than some of the ‘draft’ versions given to me by those in the field.

3.4.6 Analysis of the material

For each of the topics investigated, the analysis attempted to be systematic. The empirical material for each of the topics in turn was initially examined using the SNM categories in isolation: first and second-order learning, expectations and visions, actor-networks, and institutions. Within these ‘isolated’ analyses, connections to the other categories were identified. This was supplemented with consideration for the links and influences to and from the landscape, regime(s) and the implications at the level of the niche, particularly with regard to the socio-technical trajectories at the niche level. These fragmented analyses were then integrated, based on the interdependencies identified in the analysis of each conceptual category and, across a number of topics where there was clearly a theme connecting them. The themes then provided the basis for the form that the two main empirical chapters use. Each theme, as will be seen, is first recounted in a narrative section and this is followed by an analysis of that section.

3.4.7 Limitations of the methodology

No methodology can be without limitations. The research here is based almost entirely on qualitative data and the analysis relies heavily on interpretation. While I have attempted to be systematic in data collection, even assuming the collection *is* systematic, the nature of the sources and access to them immediately poses a problem. This is perhaps especially so in the context of developing countries. Information is notoriously unreliable, fragmented, at times inaccessible and sometimes lost; and this is particularly true of archival material. As a result, there is a heavy burden placed on the personal memories of informants who participated in the events of interest. Wherever possible, I have tried to triangulate information such as dates – a particular problem for memories – with information documented at the time and with other interviewees.

Where dates are ambiguous, I have given a best estimate or left the range unresolved. Likewise, where other, perhaps more substantive, information is ambiguous I have used the same techniques. Above all, where information cannot be said to be robust, I have tried to be transparent in the analysis and discussion so that an appropriate weight can be given to the conclusions.

Of course, interviews can be a source of bias; the interviewee may be determined to give a very partial view on the topic under investigation. I have assumed this for all the interviews. Nevertheless, in terms of the theory expressed in SNM, this is not an entirely problematic issue. Part of the interest relates to expectations and visions; an element of the theory that tries to capture a certain amount of rhetoric. If an interviewee is giving a partial view on a subject then this may reflect something of the strength of the rhetoric, revealing what they consider to be persuasive and implying or anticipating counter views. Once again, however, the analysis attempts to triangulate wherever possible and to assess the plausibility of any given view based on other available evidence on the topic.

Finally, the subject of this research covers the evolution of two niches spanning a period of about 30 years. Given the complexity of SNM as a theoretical framework, this makes for an enormous research task, especially in the context of developing countries where infrastructure is weak and unreliable. During the fieldwork, there were frequent black and brown outs in electricity supply, preventing or delaying work. There were also burdensome bureaucratic processes that exhausted weeks at a time, and securing access to some very busy informants can consume many disappointing hours. Frequently, natural phenomena impose a different timetable on the work: a significant part of my fieldwork in Tanzania was conducted during the long rains and they were particularly heavy in 2008. The result was rapidly flooding streets and power cuts, with consequent impacts on the time available to get work done or to get to meetings.

None of these issues will be news to anyone who has travelled or tried to work in countries where these kinds of conditions are commonplace. The point here is to acknowledge that these things have an impact on the practical fieldwork that can actually be achieved, and to note that this must be limiting of any methodology.

3.5 Summary of the chapter

This chapter has attempted to describe the methodology used to collect and analyse the data for this research. We have discussed the research strategy and operationalised and defined key concepts for use throughout the rest of the dissertation. The methods of data collection have been described and an indication of the methods used to analyse those data have been outlined. Finally, we have discussed briefly some of the limitations to this methodology and how these have been addressed wherever possible.

4 The Context of PV in East Africa

4.1 Introduction to the chapter

Before considering the two case studies in chapters five and six, we will use this chapter to discuss their context. We will open the discussion by sketching the evolution of relevant development economics theories, and include brief notes on the political economies of Kenya and Tanzania along the way. Following this, we will take a brief look at a number of other aspects of the context. These include a glance at some early household energy studies; the rural electrification debate; an account of the global PV niche, tracing its development from the mid 1970s to the present worldwide market; and a short discussion of the 1981 UN Conference on New and Renewable Sources of Energy. The chapter finishes with a description of the early period of the entry of PV into East Africa, where it was introduced through donor-supported programmes. This introduction of PV into Kenya and Tanzania is then analysed with reference to the various aspects touched upon in the discussions earlier in the chapter.

4.2 Landscapes and regimes

Consistent with the theoretical perspective of strategic niche management, we will refer to the elements of the context and their interactions, in which the PV niches of Kenya and Tanzania developed, as landscape and regime dynamics. This section attempts to sketch the broad contours of the landscape of development thinking, and political economies of what might loosely be described as the 'state' regimes of Kenya and Tanzania up to the present day. The discussion begins with the origins of the development economics 'paradigms', to use Hunt's (1989) term, after the Second World War. It then continues by showing the evolution of this theorising together with some description of the policy prescriptions that flowed from the approaches: the instruments and institutions of the development regime. At convenient points in the discussion, it turns to the political and economic developments that occurred in Kenya and Tanzania.

4.2.1 Development paradigms and regimes, and Kenya and Tanzania

Hart (2004:3) identifies two distinct periods of approaches to development since the end of the Second World War; the first being "State-led Developmentalism", ending around the early 1980s as the second period – the "Washington Consensus" – took hold[11]. These periods further divide into a short one of 'basic needs' during the 1970s, and two periods of the neo-liberal hegemony whereby the Washington Consensus gave way to the "post-Washington Consensus" during the early 1990s. Within the "developmentalist" period there were, up to the early 1960s, two different paradigms co-existing: the structuralist paradigm, arising out of Latin America, and the "paradigm of the expanding capitalist nucleus" (Hunt 1989:47-64).

The structuralist theory emerged out of the experiences of Latin American countries through the period up to the late 1940s, the conditions of which appeared to have stimulated the development of some "substantial industrial capacities" (Oman and Wignaraja 1991:137-139). The perspective was based on two ideas: the notion of a centre-periphery dichotomy in world capitalism; and the observation of a dual structure within the economies of developing countries (the periphery), characterised by some sectors using low-productivity technologies (such as in subsistence farming) and advanced sectors making use of much higher-productivity technologies (Oman and Wignaraja 1991:139; Hunt 1989:49). To prevent productivity gains amassing in the centre, and to transform the economic structures in the periphery, structuralists advocated a policy of industrialisation by import substitution. Consequently, this should develop a domestic market and keep more of the gains from industrialisation within the local economy.

The idea of the expanding capitalist nucleus evolved largely out of Britain and North America, where the early search for theory to underpin "economic development in the underdeveloped regions" had rejected the neo-classical paradigm as unable to provide useful insights (Hunt 1989:45-46). However, there was widespread acceptance among these economists that:

> … industrialisation was the key to economic development, and that this would not be promoted by indefinite concentration on expansion of primary exports in exchange for manufactured imports. … Most also took the view that

[11] The term *Washington Consensus* was coined by John Williamson in 1989. It has been interpreted in many ways since Williamson first used it but his original intention was to summarise "10 policy instruments about whose proper deployment Washington can muster a reasonable degree of consensus" (http://www.iie.com/publications/papers/paper.cfm?researchid=486).

> achievement of a satisfactory rate of resource mobilisation for economic development would require a substantial degree of state intervention …

The theory that was developed, based on ideas from Lewis (1954) and Rostow (1956), became the dominant paradigm outside Latin America, and held that the main characteristic of development was economic growth. This should be initiated by an entrepreneurial, or capitalist, class, as they had a greater propensity to save or invest. Following from this then, policies were advocated to "enhance the rate of profit and the command over scarce resources of the capitalist class, and, hence, the rate of productive accumulation" (Hunt 1989:63); to be achieved through "the establishment of *export* industries" (Oman and Wignaraja 1991:179, italics in original). Foreign investment would need to be attracted in order to set up these export industries; a strategy that became known as 'industrialisation by invitation'.

So, although these were different approaches, both paradigms accepted that development would be achieved through capitalism; both saw an important role for government; and both, in a sense, assumed that the benefits would 'trickle down' in time (Hunt 1989:51). However, it became increasingly apparent that the benefits were not being felt by the poor, and industrialisation was becoming dominated – under both approaches – by multinational corporations. As a result, criticisms began to emerge "both from the radical left and from the tradition of neo-classical economics" (Hunt 1989:64). Some of the Marxist and neo-Marxist critiques crystallised into various forms of dependency theory in which the centre was, in effect, deliberately holding back capitalist development of the periphery, thereby preventing the eventual emergence of socialism. The only way to development, it was argued, was to withdraw "from the international capitalist system" (Hunt 1989:67-68).

It was within this atmosphere of debate that Tanzania began its independence. From 1961 until 1967, Tanzania followed a largely Lewis-style model of industrialisation by invitation. However, the approach did not seem to be working and, perhaps through the influence of Samir Amin (an important dependency theorist in Africa) but certainly as a result of the social philosophy of Julius Nyerere[12], Tanzania adopted the "Arusha Declaration" in 1967; Nyerere's vision of an African socialism (Oman and Wignaraja

[12] Julius Nyerere was the first President of Tanganyika, which became Tanzania following the political union with Zanzibar in 1964 (Barkan 1994:9).

1991:172, 175). Kenya, meanwhile, maintained and developed a focus on economic growth, encouraging the production of cash crops, being receptive to foreign investment (Barkan 1994:5), and pursuing industrialisation by import-substitution (Ndulu and Mwega 1994:109). Relations between the two countries after independence were somewhat neutral initially, partly because they were accustomed to close ties under British rule (Gordon 1994:243). However, there were attempts, along with Uganda, to set up formal cooperation. These began with the Kampala Agreement in 1964 and were then resurrected in 1967 by establishing the East African Community (EAC). But ideological differences, and feelings that Kenya was gaining more from the arrangements, led to diminishing participation by Tanzania. It was not until the early 1980s that Tanzania began a gradual re-engagement with the EAC (Gordon 1994:246).

4.2.2 Growth and equity, or simply growth

As the 1960s unfolded, and a body of research into income distribution developed, it became increasingly apparent that, although there had been significant economic growth in many developing countries, the trickle-down effect was not materialising (Oman and Wignaraja 1991:97-98). The discussions and analyses stimulated by this realisation led to calls for a reinterpretation of the ‘measurement’ of development; from the simple focus on per capita GDP to inclusion of trends in “poverty, income distribution and employment” (Hunt 1989:71). By 1974 there was widespread consensus among donors and others involved in development thinking that poverty was the central issue to be addressed, culminating in the World Bank-IDS[13] developed policy of ‘Redistribution with Growth’ (Oman and Wignaraja 1991:100; Hunt 1989:72; Robb 2004:25). According to Hunt (1989:264):

> … a key feature [of the redistribution with growth strategy was the] continuing acceptance of certain key assumptions of the paradigm of the expanding capitalist nucleus. Thus the most dynamic sector of the economy is the modern sector, and within this it is the rich, and presumably the rich capitalists in particular, that are assumed to have the highest propensity to save and invest. Any redistribution of income from rich to poor is therefore bound to slow down economic growth.

[13] IDS is the Institute of Development Studies, located at the University of Sussex in Brighton in the UK. The report is called *Redistribution with Growth*, authored by Chenery, Ahluwalia, Bell, Duloy and Jolly (1974).

To minimise this tension between growth and equity, the strategy recommended a limited (2% of GNP annually) redistribution through public expenditure of the gains from modern sector growth to be invested in measures to raise productivity and incomes of the poorest 40% (Hunt 1989:264; Robb 2004:25). However, some suspected that this would be achieved by concentrating on the “top end of the poverty range”, with the consequence that the very poorest would see no benefits at all (Hunt 1989:264).

Alternative analyses converged on a strategy for poverty reduction through land redistribution, accumulation of human capital, and growth based on an intensive use of human resources (Hunt 1989:265). Other aspects of the issue of poverty were also raised, including the less material aspects such as human rights and access to decision-making. In 1976, the ILO endorsed “a proposal that national development strategies should place a high priority on both the generation of employment and the satisfaction of basic human needs” (Oman and Wignaraja 1991:105). Robb (2004:25) states that the impact of the basic needs approach was significant, at least in terms of donor intentions and to some degree in their interventions, and Oman and Wignaraja (1991:106-107) characterise the approach as much more radical than the redistribution with growth strategy. The basic needs approach addressed poverty directly and, it was hoped, more rapidly than redistribution, and included needs that were non-economic as well as political.

Basic needs also offered an opportunity for the mainstreaming of the notions of development through appropriate technology, which aligned easily with the rural focus and labour-intensive approach. Schumacher’s *Small is Beautiful* was published in 1973 and a worldwide appropriate technology movement grew rapidly in the decade or so following this (Carr 1985:5). And, of course, these debates took place in the context of the publication of *The Limits to Growth* in 1971, the first oil crisis in 1973, and a burgeoning environmental movement, contributing to a general questioning of the assumptions of ‘standard’ growth models and industrialisation (Smith 2005). It is therefore unsurprising, as Oman and Wignaraja (1991:104-105) note, that within this context and seeing such activity, Mahbub al Haq argued in 1976 that “development practitioners and theoreticians had accepted that the market mechanism was not an efficient method of resource allocation under conditions of an unequal distribution of income”.

However, analysis from the neo-classical perspective was not silent during this period; it continued to criticise interventions other than those that would facilitate the removal of market distortions. The confluence of a number of factors led to the resurgence of the neo-classical influence and its subsequent domination of development thinking from the early 1980s. Developing countries began to suffer increasing debt burdens as a result of the oil-price shocks in 1973/1979 and, linked to the high price of oil, world economic growth slowed (IEA 2004:6). Moreover, according to Woo (1990:412-413), the plausibility of development economics began to collapse as a result of neo-classical studies, conducted during the 1970s, of trends in growth and equity in a range of developing countries. These showed that countries with the fewest "policy-induced distortions" – and interpreted to be using export-led strategies – did better in growth terms *and* equity terms, undermining the credibility of import-substitution strategies and falsifying the long-held belief in the Kuznets[14] curve.

In 1979, the World Bank began a programme of Structural Adjustment Loans, carrying with them IMF conditionality that the borrowing country agree to supply-side policy measures (Oman and Wignaraja 1991:83). Robb (2004:27) lists these as including "monetary restraint, reduction of barriers to trade, liberalization of exchange rates, reduction of budget deficits and downsizing of the public sector". In 1982, Anne Krueger, a leading figure in the neo-classical "counterrevolution" became vice president of development policy at the World Bank, following the resignation of the "structuralist Hollis Chenery" (Woo 1990:415). Together with the political difficulties of implementing the more radical elements of the basic needs approach (such as land reform), the resurgence of the neo-classical paradigm spurred some basic needs advocates to focus more on promoting the provision of public services and investment in human capital; elements of the approach that may have been more aligned with neo-classical thinking (Hunt 1989:270-271). Nevertheless, as the 'Washington Consensus'

[14] Following a paper by Simon Kuznets in 1955, the 'Kuznets curve' suggested that income inequalities are high where per capita income is at some intermediate level but fall with higher per capita income; an inverted U-shape. According to Woo (1990:411), most development economists believed in the trickle-down effect and so were not overly concerned that inequality was increasing, believing that the poor were not being further impoverished; that their incomes were simply rising more slowly than the wealthy, and that eventually their incomes would converge *a la* Kuznets' curve. The falsification of the Kuznets curve put this belief in severe jeopardy.

gathered strength and structural adjustment was more widely applied, the basic needs paradigm faded from prominence (Robb 2004:30).

By the end of the 1970s and into the first half of the 1980s, Tanzania and Kenya were experiencing both political and economic decay (Barkan 1994:21). Tanzania already had serious economic problems by the mid 1970s when “the expected surplus from agricultural production had not materialised” (Oman and Wignaraja 1991:177). This was exacerbated by Tanzania’s unwilling occupation of Uganda over the period 1979 to 1985, following the ousting of Idi Amin, causing a crippling drain of its resources (Gordon 1994:246). Indeed, GDP per capita in Tanzania fell by 2.4% in the period 1981 to 1985, and corruption rose as members of the civil service and elected officials increasingly engaged in rent-seeking (Barkan 1994:21, 22).

According to Gordon (1994:253), Tanzania looked for financial assistance from the international community but became “locked in a struggle with the IMF over access to much-needed IMF resources, and to the resources of the World Bank and other donors that would follow the signing of an IMF agreement”. One of the problems was President Nyerere’s position as a radical voice in the Non-Aligned Movement, constraining the compromises he could make with the IMF. Moreover, Barkan (1994:28-29) argues that Nyerere understood that any acceptance of IMF conditionality would inevitably lead to political reforms and the end of Tanzania’s socialist experiment. Eventually, an agreement was signed with the IMF, but only after Nyerere had retired and was succeeded in 1985 by his more pragmatic vice president Ali Hassan Mwinyi.

Following the implementation of structural adjustment, the economy began to recover growth during the second half of the 1980s, but the impact on social programmes was severe and there was a perceived cleavage along ethnic lines of winners and losers in Tanzania’s ill-developed private sector (Barkan 1994:29-30). Mwinyi also helped to further the warming of relations again between Kenya and Tanzania after they had become hostile over a dispute about Kenya’s forming of its own airline using equipment from the EAC in 1977 (Gordon 1994:246). Tanzania had retaliated by closing the border; only opening it again in 1983, with relations beginning to mend before Nyerere left office in 1985.

The story of Kenya's interactions with donors, under the leadership of Daniel Arap Moi, was quite different over this period to that of Tanzania. Although Kenya also received assistance from international financial institutions, the assistance was without conditionality as the country had already, in 1982, independently initiated some stabilisation and adjustment policies (Barkan 1994:35). Moi also enhanced Kenya's relationship with the US, providing a strategic location in East Africa for US military presence in the manoeuvres of the Cold War. This helped Kenya to become "a major recipient of quick-disbursing foreign aid" from Western donors and supported Moi's "increasingly dictatorial" leadership, characterised by his "centralizing political power into his own office, rewarding ethnic compatriots, and repressing dissent" (Gordon 1994:58). But the donors were tolerant of Moi, partly because he managed to impress them with commitments to reform, even if he tended to fall short in their implementation. In the meantime, the economy continued to suffer, with per capita growth in the rural areas turning negative in 1988; there was increased corruption by Moi and others in his government; and human rights abuses mounted as Moi's "regime turned progressively inward and became more repressive" following an attempted coup in August 1982 (Barkan 1994:25, 27, 35-36). Still, the West was reluctant to openly criticise Kenya; US official policy was to not "rock the boat" (Gordon 1994:258).

4.2.3 End of the Cold War

Soon after the ending of the Cold War, the international community began to adopt the notion that successful development and good governance were interdependent (Gordon 1994:255). In 1990, the main donor governments of the West announced that aid to any country in Africa would be dependent on "good governance and respect for human rights" (Chege 1994:49). As with the economic approaches to development, there was no firm theoretical consensus on which to come to the notion that good governance was important; it may have been more to do with the fact that the West no longer had to court strategic interests in its battle with communism, particularly in Africa (Gordon 1994:258). Instead, it seemed, the neo-classical paradigm was sweeping others aside and democracy could do the same. In any case, the donors began increasingly to call for political as well as economic reforms.

However, the theoretical battle over the Washington Consensus was not over. Hart (2001:652) notes that, as early as 1989, "a powerful missile in the form of claims that South Korean state functionaries had systematically violated some of the most sacred tenets of neoliberal orthodoxy" was "lobbed" by Alice Amsden. Others followed soon after with accounts of how state intervention had played an important role in the 'East Asian Miracle'. The consensus, however, appeared to be unbroken until the Asian financial crisis in 1997. That was blamed on an "absence of market infrastructural institutions" in the East Asian economies, causing the 'consensus' to shift from a focus on prices to a focus on institutions (Woo 2004:22). With the Millennium Development Goals now on the international agenda, and the state brought back in, the current development thinking was beginning to look like a return to the basic needs approach, at least in its less radical sense.

The end of the Cold War was highly significant for Kenya and Tanzania, although Moi was slow to understand this. Nyerere, on the other hand, saw the implications and used his influence to initiate political reform in Tanzania. For both countries, it stimulated processes that eventually led to multi-party democracy. Moi resisted the pressures coming from within Kenya and from donors but eventually relented after the donors suspended quick-disbursing aid in 1991. Almost immediately, Moi announced the reinstatement of multi-partyism together with a number of other reforms (Barkan 1994). In Tanzania, Nyerere was the first to publicly accept that multi-party democracy was inevitable, couching his acceptance in terms of it being the right time for Tanzania to embrace the idea. In 1993, Tanzania officially became a multi-party democracy and, as with Kenya, a number of other reforms followed quickly (Gordon 1994:261-262).

However, unlike Kenya, Tanzania saw a peaceful transition to a new president in 1995 and again in 2005. Moi won the election in Kenya in 1992 and again in 1997 because of a highly fragmented opposition but, in each case, there was "unprecedented … violence and foul play" (Barkan 2004). However, in 2002, the opposition managed to hold together under National Rainbow Coalition (NARC) and won a landslide victory against Moi's replacement Uhuru Kenyatta (Barkan 2004). Before the next election in 2007, partly because of disagreements over the constitution referendum in 2005, NARC fell apart. The main figures of the former NARC – Mwai Kibaki and Raila Odinga – were rivals in the election, leading the Party of National Unity (PNU) and the Orange

Democratic Movement (ODM) respectively. With no clear front runner, two large power bases pitted against each other, and a number of irregularities emerging during the counting process, once again there was widespread violence across ethnic lines for some weeks following the election (Branch and Cheeseman 2008:2). Kibaki claimed the office of president, but some level of peace was not restored until the position of prime minister – originally promised as part of the 2002 election campaign – had been offered to Odinga.

In terms of relations through the EAC, the three countries signed an agreement in December 1993 to re-establish the community after it had failed to implement any concrete actions since the rapprochement in 1983 (Gordon 1994:247). The agreement included commitments to the free movement across borders of people, goods and services, and cooperation on foreign policy. There was also to be a common East African passport, cooperation on economic policies, and the removal of tariffs within the region (Bigsten and Danielson 2001:27). In 2000, the EAC Treaty came into force and, in 2007, Rwanda and Burundi joined the community (EAC 2009).

4.3 Energy, technology and developing countries

This section contains brief discussions of a number of aspects of the context of our case studies. It begins with a look at how rural energy use in developing countries came to be studied in detail following the oil price shocks of the 1970s. Those studies found that biomass was the biggest source of energy-use in rural households, prompting fears of another energy crisis in addition to fears of oil-dependence. The discussion then turns to rural electrification and gives an indication of the debates around the issue of whether it contributed to development. We then sketch the development of the global PV niche, from the R&D interest in the 1970s, following the oil-price shocks in that decade, up to what is now a rapidly growing market for PV technologies worldwide. In the process, we will describe some of the technical evolution of PV but also discuss how the expectations for its use developed. One of the other international responses to the oil shocks was a UN conference in 1981 and that is the topic of the next brief discussion. Finally, we look at the early experimental PV systems that were installed in East Africa and supported by donor programmes, particularly the US Agency for International

Development (USAID) and the World Health Organization Expanded Programme on Immunization (WHO-EPI).

4.3.1 Codifying household energy-use in rural areas

The oil crisis in 1973 spurred interest in energy in developing countries and its role in development. A number of studies of energy-use in developing countries emerged throughout the 1970s, focused on different levels of the total energy-use picture. Within this move to understand better the patterns of energy-use in developing countries, household energy consumption began to be taken seriously. Prior to this, 'energy demand' had meant *commercial* energy demand: the use of energy for industrial and transport sectors in the economy. During the 1970s, the household energy economy began to be studied more systematically. In Kenya, "[a]s late as 1978 the belief was still widely held that of all the primary energy consumed …, about 80 per cent came from imported oil. But by 1980, the role of wood, charcoal and crop-wastes as fuels became generally recognized" (Goodman 1984:i).

Two studies in Kenya helped to contribute to this recognition, one conducted by the CBS (Central Bureau of Statistics) together with the NCST (National Council for Science and Technology), and one by the Forestry Department of the Ministry of Environment and Natural Resources (Hosier 1985:29). At about the same time as these studies were being undertaken, there was interest from the Beijer Institute to research issues of energy and development, and Kenya was chosen as a case study for East Africa (Goodman 1984:i). The CBS/NCST and Forestry Department surveys were conducted during October and November 1978, and between April 1979 and January 1980, respectively (Hosier 1985:31, 37).

The Beijer Institute's Kenyan Fuelwood Project was a long time in discussions and planning before it gained support from the Kenyan Government. The research had been initiated in November 1977, but it was not until May 1979 that the Government became involved; initially, through the Ministry of Power and Communications and then the Ministry of Energy, after it had been formed later the same year (Goodman 1984:i). One of the findings of the Beijer study was the dominance of cooking energy needs in the rural household sector, and that these needs were met almost entirely from "non-commercial" sources (O'Keefe *et al*. 1984:27):

> … it was discovered that regardless of income class, biomass constitutes the overwhelming basis for rural energy consumption. Electricity does not occur as a significant factor primarily because of limitations in the extent of the distribution grid. Kerosene accounts for only … 1 per cent of demand.
>
> … Cooking emerges as the overwhelming end-use allocation of energy, accounting for … 98 per cent of demand. Lighting, the other end-use reported by a significant number of households, accounts for the remainder.

In terms of the *total* end-use consumption of fuels in Kenya in 1980, the study found that 53% was used for rural household energy needs (O'Keefe *et al*. 1984:24). Considering that this pattern of consumption was unsustainable, it was clear that a priority for energy interventions would likely be the cooking practices of rural households. Indeed, soon after this, USAID supported a large project in Kenya to develop an efficient charcoal stove. That became the Kenya Ceramic Jiko and continues to be sold in large numbers, even to the present day (Bess 2002; Hankins 2007).

4.3.2 Rural electrification

Although rural electrification had been underway in developing countries for some time, there had been little systematic study of its impact. One of the few studies that had been done was conducted in Kenya in the mid 1970s by Hjort (1974). That study was "intended to bring out social and economic effects of rural electrification on the local level" (Hjort 1973:abstract). The final report was unavailable for this research, but it was used along with a number of others from around the world in a paper by Wasserman and Davenport (1983) as part of a long period of reflection by USAID[15] concerning its rural electrification intervention strategy. This period of reflection had been stimulated by a change in US foreign assistance policy that was intended to target the poor, and particularly the rural poor, more effectively. The new policy was influenced by the basic needs approach and became known as 'New Directions' (McGuire and Ruttan 1990:128). USAID had been supporting rural electrification

[15] USAID were the first donor to support rural electrification in developing countries, followed soon after by the World Bank (Davenport 1983:A1); an infrastructure development approach that was normal practice in the early days of development interventions (Robb 2004:23). This rethink about rural electrification was something many donors did around the same time as USAID (Barnett 1993:100).

projects but these were now considered, from the New Directions perspective, to be ineffective for poverty reduction (Tendler 1979:v).

The various reviews that USAID commissioned on the subject proved inconclusive. Wasserman and Davenport (1983:5) found that rural people wanted electricity but it was difficult to get connected, even when the grid was nearby, because of the connection cost. There was conflicting opinion about whether the poor could afford to operate appliances if they did manage to get connected to the grid. A review by Tendler (1979:16) suggested that the poor who did get connected tended to use the electricity only for powering lights; that other appliances were generally too expensive to buy, or too expensive to operate. The paper by Wasserman and Davenport (1983:5), however, suggested that operating costs were not a problem. And a later review by Pearce and Webb (1987:330-332), of a number of studies from the 1970s to the early 1980s, suggested that no general conclusions could be drawn regarding the impact of rural electrification on the poor, howsoever defined.

Tendler's (1979:26) main recommendation to USAID was that they should identify community services or income generating opportunities that could be attached to a rural electrification project. Such projects would be able to get past what she called "New-Directions critics" (Tendler 1979:v). But it was not just "New Directions critics" that USAID needed to please, there were competing forces coming from Congress to spend US tax dollars in a way that benefited the US economy and, as market fundamentalism began to emerge more strongly at the beginning of the 1980s, to only engage in projects that were market-friendly. Accommodating these various forces, USAID elaborated their policy on energy assistance in 1981 (USAID 1981:15, 17-18):

> These [various energy] technologies are in different stages of development and application. Technology assessments are needed to match energy needs in developing countries with prospective technologies and to establish priorities for U.S. Government research, development, demonstration, and investment for developing country applications.
>
> The United States is spending several billion dollars a year to develop and demonstrate energy technologies aimed at meeting our own domestic energy requirements. Most of these technologies have attractive applications in developing countries, either in their present form or with some modifications. A systematic review and analysis of U.S. research and development is required to identify and adapt these systems for potential developing country use.

> … AID should support the site testing and demonstration of potentially attractive technologies that are ready for application and careful evaluation. With the strengthening of developing country capability in energy technology and a well-structured analysis of applications, developing country specialists and institutions can learn which technologies are appropriate for each individual setting and can formulate programs for their widespread utilization.

So, there was a clear attempt to connect their energy project interests to the R&D programmes in the US, and to suggest that there were potentially large markets for these new technologies in developing countries. The implication was that USAID would be marketing US technology. Indeed, the 'tying' of donor support to technology from the donor country became common practice among aid agencies (Robb 2004:23; Berríos 2000). This was one way to 'sell' aid to a domestic public, or to a sceptical part of that public, and so an argument for maintaining a programme of bilateral aid. However, certainly in the case of the US, the main reason for maintaining a bilateral programme was to use it as an instrument of foreign policy (McGuire and Ruttan 1990:147-148; Berríos 2000; Robb 2004:29).

4.3.3 A global PV niche

In any case, the US was serious about researching the potential for replacing oil in its economy. PV technology was already in use in some highly specialised applications, beginning with the space programme (to power satellites) and branching into the oil industry (for pipeline protection and lighting of buoys to warn of off-shore oil platforms) (Costello and Rappaport 1980; Perlin 1999). The oil crisis spurred a number of governments to search for alternatives to fossil fuels, but the most active was the US (Morse and Simmons 1976; Brown and Hendry 2009). In a paper for the *Annual Review of Energy*, Morse and Simmons (1976:153) stated:

> Solar energy R&D programs are underway in many nations other than the United States, especially in Germany, France, Japan, USSR, and Australia. However, the US program is by far the largest, with a budget in fiscal year 1976 of about $110 million.

More recently, a study of US Federal R&D spending on energy development, over the period 1950 to 2006, concluded that PV had received the largest share of the total for renewable energy technologies, with USD 3.4 billion[16] spent on the photovoltaics programme in the period 1976 to 2006 (MISI 2008:72). It is interesting to note that US Federal spending on PV was ramped up very quickly during the late 1970s, only to be reduced at a similar rate during the early 1980s (see Figure 4.1). One explanation for this rapid reduction in Federal R&D on PV could be the election of Ronald Reagan to the White House in 1981 and his Administration's application of market fundamentalism. However, subsequent Administrations did not raise R&D spending on PV either; it hovered around USD 80 million[17] annually up to 2006, only going above USD 100 million in 1994 and 1995 (MISI 2008:71).

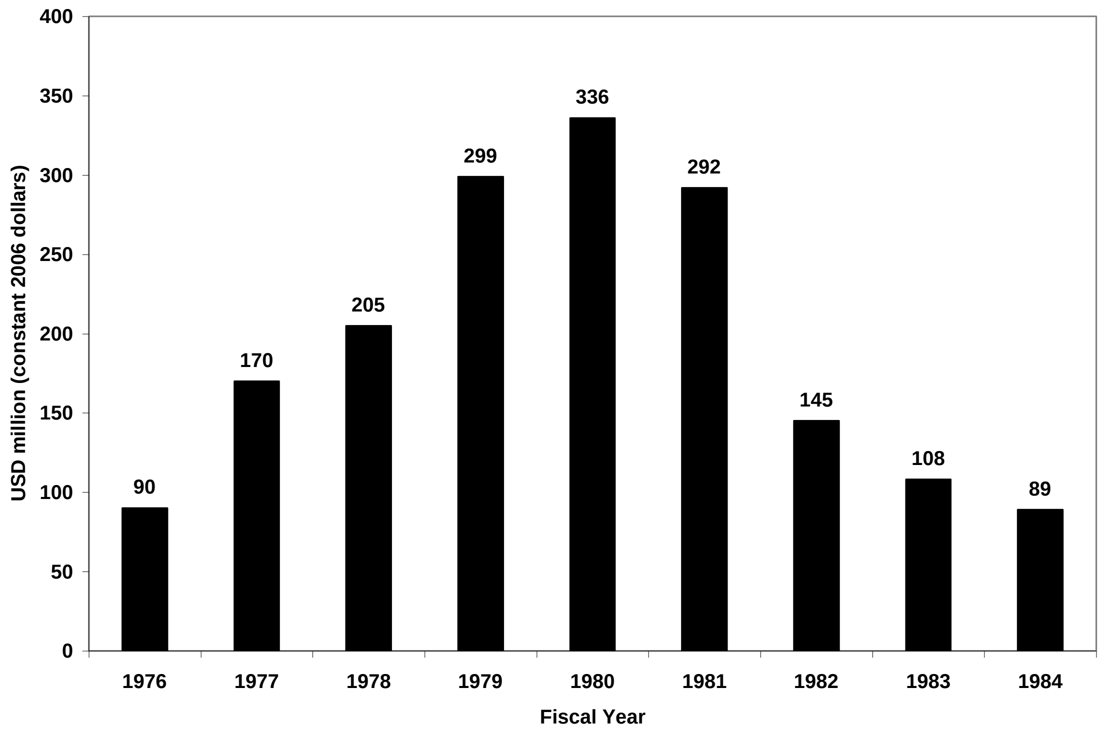

Figure 4.1: US Federal PV energy systems R&D, 1976 to 2006, constant 2006 USD
Source: Adapted from MISI (2008:70-72)

Other countries began to challenge this initial US dominance, particularly in terms of demonstration systems and trials with PV, in order to stimulate their own markets and to develop indigenous PV manufacturing industries. Most notable among these were Germany, France and Japan, beginning in the 1970s then becoming more ambitious over time (Durand 1980; Brown and Hendry 2009). But more recent developments

[16] The figures are given in constant 2006 USD. In the 1976 to 2006 period, PV received 20% of the R&D spent on renewables, and over the period 1950 to 2006 renewables altogether received 14% of Federal R&D on energy technologies (MISI 2008:17, 72).
[17] As before, the figure is in constant 2006 USD.

mean that yet other countries could become the most significant in manufacturing terms and in domestic markets for the technology. China is expected to be one of these, but others such as India might also be important. And the US is expected to develop a significant market over the long term (EPIA 2010).

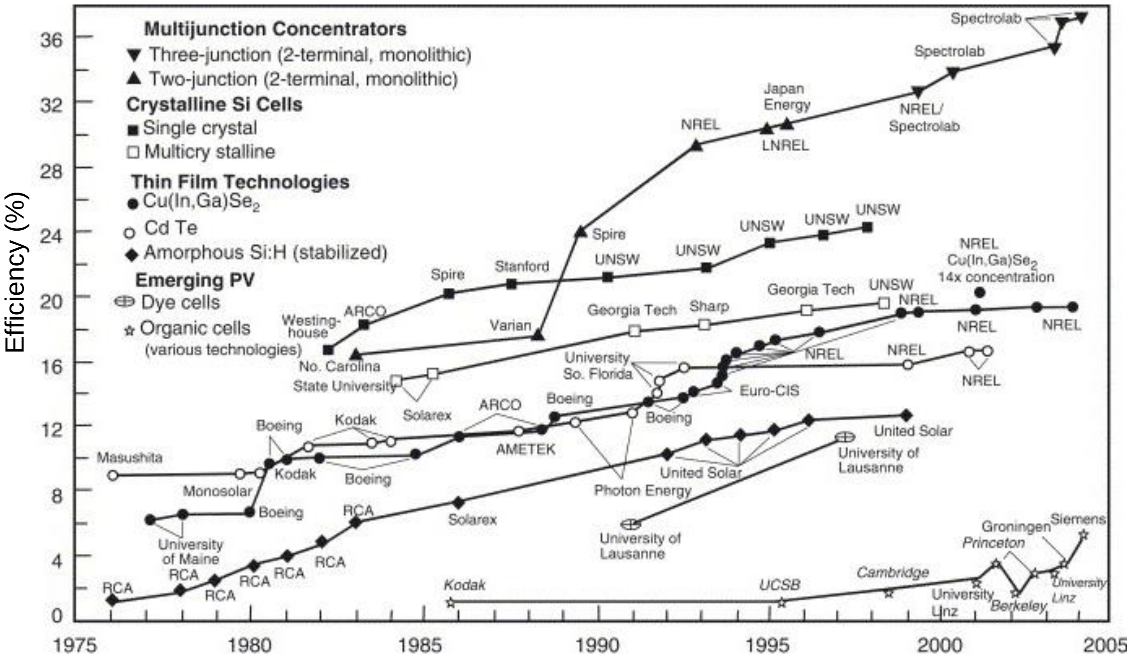

Figure 4.2: Progress in solar cell efficiencies for various research or laboratory devices from 1976 to 2004

Source: Surek (2005:293)

R&D spending on PV has been applied to a range of approaches, partially because the photovoltaic effect is possible to achieve using a wide variety of materials and forms of PV-cell (Costello and Rappaport 1980). Crystalline silicon (c-Si) cells were the focus of initial experiments, following the discovery of the photovoltaic effect by Edmond Becquerel in 1839, furthered by successful cell fabrication in the 1950s and rapid improvement in their light-to-electricity conversion efficiency (Shah, Torres, Tscharner, Wyrsch and Keppner 1999). But research into other materials and forms of silicon was initiated over time, and now there is a proliferation of PV technologies, not all of which have been commercialised. Figure 4.2 shows laboratory achievements in cell efficiencies for a range of types, covering the period 1976 to 2004. However, commercial modules[18] do not achieve these figures; they are usually in the range of 50 to 65% of these efficiency levels (OBES 2005:16).

[18] For crystalline silicon, cells are connected together in series (to increase voltage) and the cell-series are connected in parallel (to increase current) before being encapsulated against the elements. The combination of voltage and current gives power, which is usually rated as watt-peak (Wp) under standard

Apart from c-Si cells shown in Figure 4.2, the other forms are as follows. Multi-junction cells use two or three layers of cells that are responsive to different wavelengths of light, thereby generating more electricity within the same surface area (Costello and Rappaport 1980). Thin film technologies refer to a completely different manufacturing process to the individual fabrication of c-Si cells that are then connected together in series and parallel. Thin films are made by depositing the photovoltaic material directly onto a substrate. This process can be much cheaper than the more ‘traditional’ individual cell manufacturing process because there is far less waste material and it lends itself to continuous production processes (Durand 1980). The film can be either crystalline or amorphous. The thin-film materials referred to in Figure 4.2 are copper indium diselenide ($CuInSe_2$, or CIS), copper gallium diselenide ($CuGaSe_2$, or CGS/CIGS) and cadmium telluride (CdTe). The technologies under the emerging category are dye-sensitised titanium dioxide (TiO_2) and those made from organic compounds. Of most interest to us in this dissertation are crystalline silicon and amorphous silicon (a-Si) modules, as these have been the main technologies available in Kenya and Tanzania. Nevertheless, there is a university research interest in both countries around dye-sensitised TiO_2 cells, as these do not require the kinds of ultra-clean manufacturing environments of silicon-based PV. This makes them attractive as technologies for future developing-country manufacture, particularly in the lower-income countries where the investments and capabilities needed for other PV technologies could be difficult to establish (Rabah, Ndjeli and Raturi 1995; Aduda 2008). Furthermore, Grätzel (2003), the inventor of the cell, claims the technology could be much lower cost than conventional PV.

Although most of the spending on PV up to around 1980 was allocated to TNCs (Transnational Corporations) (Biswas 1983:125, citing Klaus Sahlgren), which was perhaps focused on technical research, some of the early effort was targeted at economic and market analyses. Richard Tabors of the Energy Laboratory at Massachusetts Institute of Technology provided a paper in 1978 that attempted to address both these

test conditions. The encapsulated sets of cells are called modules. However, other types of PV forms that do not use sets of cells, such as thin film technologies (see the later discussion), are also referred to as modules when they are encapsulated.

aspects. He identified three types of markets for PV: one in which it was already cost-effective; a second in which it was cost-competitive; and, a third (Tabors 1978:2-3):

> The final market for photovoltaic power systems is the one at which the US DOE photovoltaic program is aimed; that of replacement of fossil energy in the United States energy economy. This final objective requires exceedingly low priced hardware from a low of under 10¢ to a high of slightly over $1 per peak watt.
>
> Each of the three demand categories listed above is important to the program and to the “industry”. The first two must be seen as a means to an end from the point of view of the Federal program though these two may represent significant sales potential from the point of view of many of the industrial firms involved.

As we have seen above, the US was highly active in renewable energy technology R&D, especially in PV, driven, at the federal level, by a desire to find alternatives to oil and, at the commercial level, by companies looking for new markets and growth. Moreover, according to Morse and Simmons (1976:153), this programme was “very aggressive, with a high priority on the earliest possible demonstration of feasibility of each of the approaches to solar energy conversion”. Economic analyses of PV systems suggested that the technology was viable under certain conditions but needed significant reductions in cost to become viable as a technology for the US. The conditions under which the technology was already viable were similar to those in developing countries: electricity supply in remote locations where infrastructure was poor or non-existent, or where it was difficult or expensive to transport fuels.

This active R&D effort in the US and elsewhere did succeed in reducing the cost of PV modules rapidly during the late 1970s (see Figure 4.3) to the point at which a study conducted in 1986 for the US Department of Energy and USAID found PV systems to be the least-cost option in a number of developing-country contexts. Specifically, based on a life-cycle analysis of 1260 “lighting and home power” systems in 14 countries, the study found that PV systems[19] were the cheapest option for loads of 1 kW or less (Eskenazi, Kerner and Slominski 1986:8). However, the Eskenazi *et al*. study is not

[19] The study examined a range of applications: water pumping, communications, vaccine refrigeration and multi-use systems, in addition to lighting and home power. In all applications, the authors concluded that PV was the least-cost option for loads less than 1 kW. For loads above 20 kW, PV was not the least-cost. For loads in between, each case would have to be assessed individually. The “base case” lighting and home power system used a 76 Wp array, had 0.6 kWh of storage and powered 20 and 10 W fluorescent lamps for 6 and 12 hours per day (Eskenazi *et al*. 1986:19).

explicit about the countries from which their data were derived. This matters because, as Nygaard (2009:10) notes, the actual price of PV to the consumer will depend on taxes and various transaction costs. There are also balance-of-system (BOS) components (e.g. batteries, loads, control equipment, cables, and so forth), each also subject to taxes and transaction costs. This can mean the same system costing far more in one part of the world than another. Indeed, Nygaard reports that a Ugandan might pay twice that of an Indian consumer, and that African prices tend to be higher in general than elsewhere.

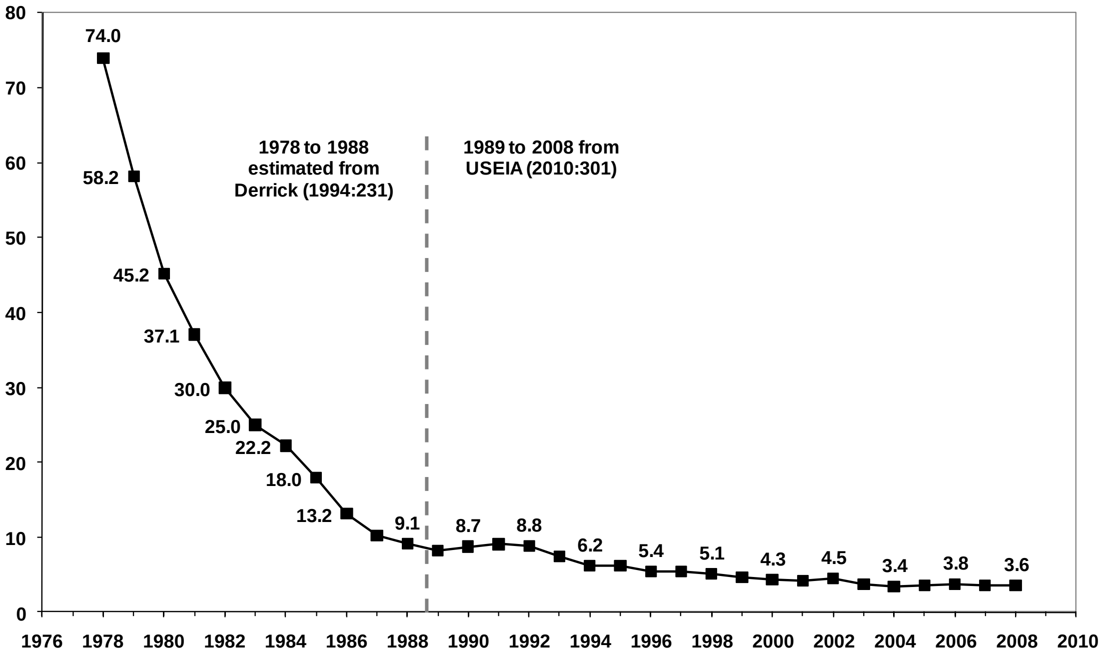

Figure 4.3: PV module shipped price in constant 2010 USD, 1978 to 2008
Sources: Derrick (1994:231) and USEIA (2010:301), as shown

We have scant data for PV-system prices over time in Kenya and Tanzania. Figure 4.4 shows the world shipped module price from 1992 to 2008 together with some indications of system prices in our case-study countries. However, care should be taken with these system prices, particularly those for Tanzania prior to 2003 as these are single figures taken from project proposals and a quotation. The other prices, while averaged over a number of systems and so potentially reliable, are based on different sorts of modules (amorphous and crystalline) and sizes (given with the sources in Figure 4.4). This presents a comparability issue and so we should take these figures only as indicative. If they are usefully reflective of market prices then a 53 Wp system would have cost a Kenyan almost 2000 dollars in 1993, and a Tanzanian would have paid 347 dollars for a 10 Wp system in 1992 (both prices in constant 2010 USD and inclusive of installation). The Kenyan's 53 Wp system would have been able to power four small lights (Hankins and Bess 1994:11), while the Tanzanian would be able to power only one small light (Kasaizi and Hankins 1992:25). Comparing such prices with GDP per capita over a similar time period (see Figure 4.5), we can see that these systems would have been out of reach of most people. Even the current system prices, although much lower than in the past, equate with several months of GDP per capita in either Kenya or Tanzania. Despite these cost barriers, private markets for household PV systems have developed in both countries. In the Kenyan case, it is surprising that the market was already beginning to thrive as early as 1992; in the Tanzanian case, it is unsurprising that a market did not develop in parallel with that in Kenya. However, PV systems were still expensive in Tanzania when a private market did begin to grow (rapidly) in the early part of the 2000s. We will explore in the next two chapters how these two markets evolved.

Although it is clear that PV systems were expensive in Kenya and Tanzania, various studies had, as we have mentioned above, identified some applications in developing countries where it was cost-competitive with other options such as diesel generators. As such, these markets were considered important for helping to bring down the cost of PV by increasing manufacturing output (Ashworth 1980; Costello and Rappaport 1980; Eskenazi *et al*. 1986; Derrick 1994; Nygaard 2009). Various ideas were in circulation concerning the form this market development might take. Ashworth (1980), for example, discusses the notion of solar villages to be powered using a range of renewable energy technologies (PV, biogas and windmills) and describes a UN Environment Programme (UNEP) plan to experiment with this idea in Sri Lanka, Senegal and Mexico. While Ashworth is critical of the way in which these "living laboratories" were to be implemented, he also elaborates how they offered a chance to envision an expectation of development with renewable energies (Ashworth 1980:258):

> Solar villages are not just large demonstration projects. They carry within them a model of what the course of development will be after renewable energy technologies have been introduced and adopted. As models, their success or failure will be central to the attitude of Third World planners and development institutions toward renewable energy technologies.

The solar village plans were most likely highly ambitious, and it is not clear the extent to which they were realised, but other applications were widely recommended or discussed. For example, as noted above, the Eskenazi *et al*. (1986) report identified a range of applications for PV systems, as did Derrick (1994): water pumping, telecommunications, and health care systems such as vaccine refrigerators, among others. Indeed, these kinds of systems, as we shall see below, were the first to be introduced to Kenya and Tanzania.

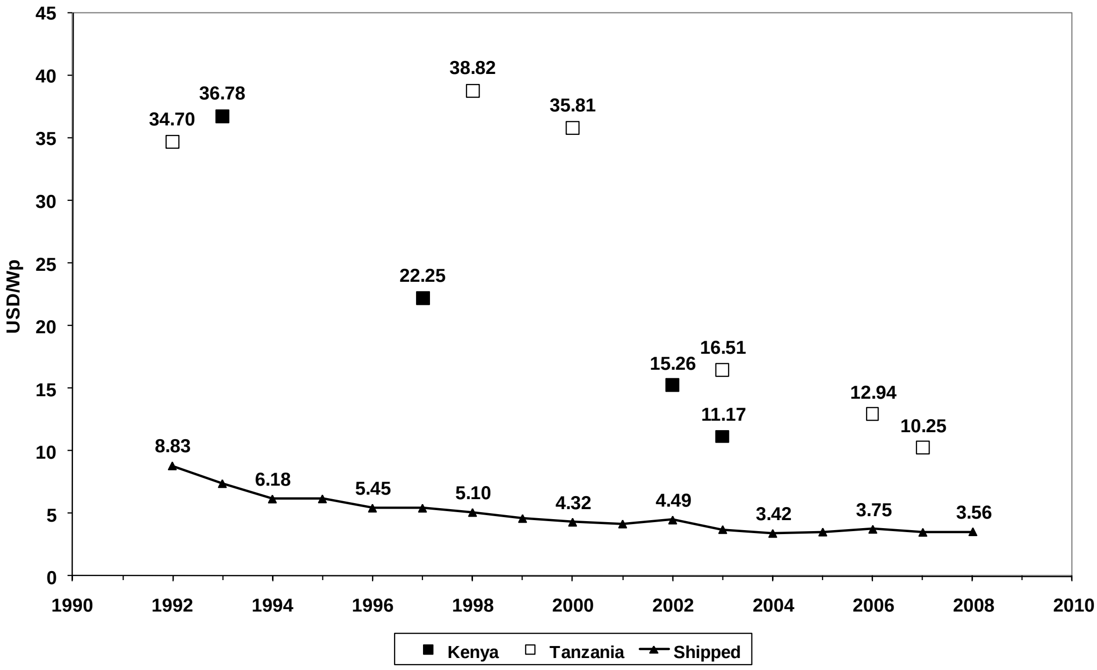

Figure 4.4: World shipped module price and indicative system prices in Kenya and Tanzania in constant 2010 USD per Wp, 1992 to 2008

Sources: **Kenya**: 1993, Hankins and Bess (1994:11) (53 Wp); 1997, Hankins, Ochieng and Scherpenzeel (1997:33) (average price; range USD 14 to 26); 2002, Jacobson (2004:145) (60 Wp; range USD 13 to 19); 2003, ESD (2003:13) (50 Wp)

Tanzania: 1992, Kasaizi and Hankins (1992:25) (10 Wp); 1998, Hifab-TaTEDO (1998:54) (50 Wp); 2000, Arkesteijn (2000:19) (20 Wp); 2003, ESD (2003:13) (50 Wp); 2006 and 2007, Felten (2008) (average price)

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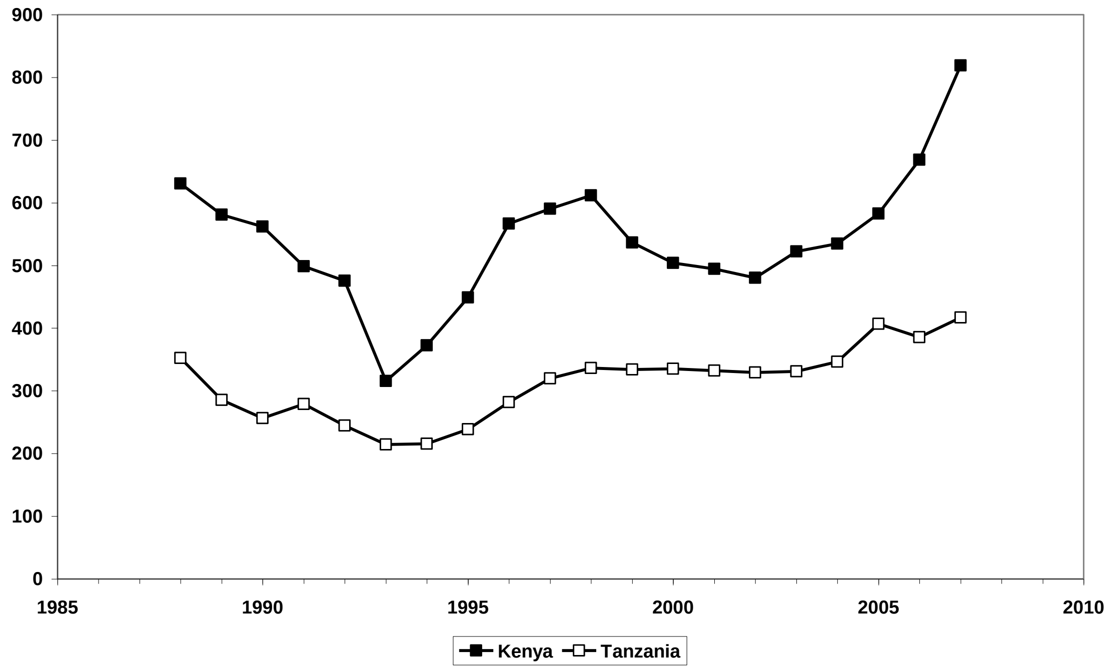

Figure 4.5: Kenya and Tanzania GDP per capita (constant 2010 USD), 1988 to 2007
Source: African Development Indicators (2009)

Over time, and particularly following the UN conference on Environment and Development in Rio de Janeiro in 1992 from which the Global Environment Facility (GEF) was – amid controversy – established (Porter and Brown 1996; Young 2002; Najam and Cleveland 2003), there has been continuing effort to experiment with PV in developing countries. The GEF, for example, has implemented many projects. By 2000, according to Martinot, Ramankutty and Rittner (2000:1), the GEF had helped to fund 23 off-grid PV projects in 20 countries, providing USD 210 million of the total project cost of USD 1.4 billion. We examine two of these in some detail in our case studies, one each in Kenya and Tanzania.

While there has been a continuing interest in off-grid PV projects in developing countries, and the market for off-grid systems has grown, the emphasis of market development has shifted more recently to industrialised countries. In conjunction with lower costs for PV, many industrialised countries have sought to promote low-carbon energy technologies and this has helped, particularly through the use of feed-in tariffs, to achieve rapid growth in PV sales. In 2009, as Figure 4.6 shows, the world market exceeded 7 GW. Europe is the leading region but other countries are expected to become important markets over time, especially the US, China and India (EPIA 2010).

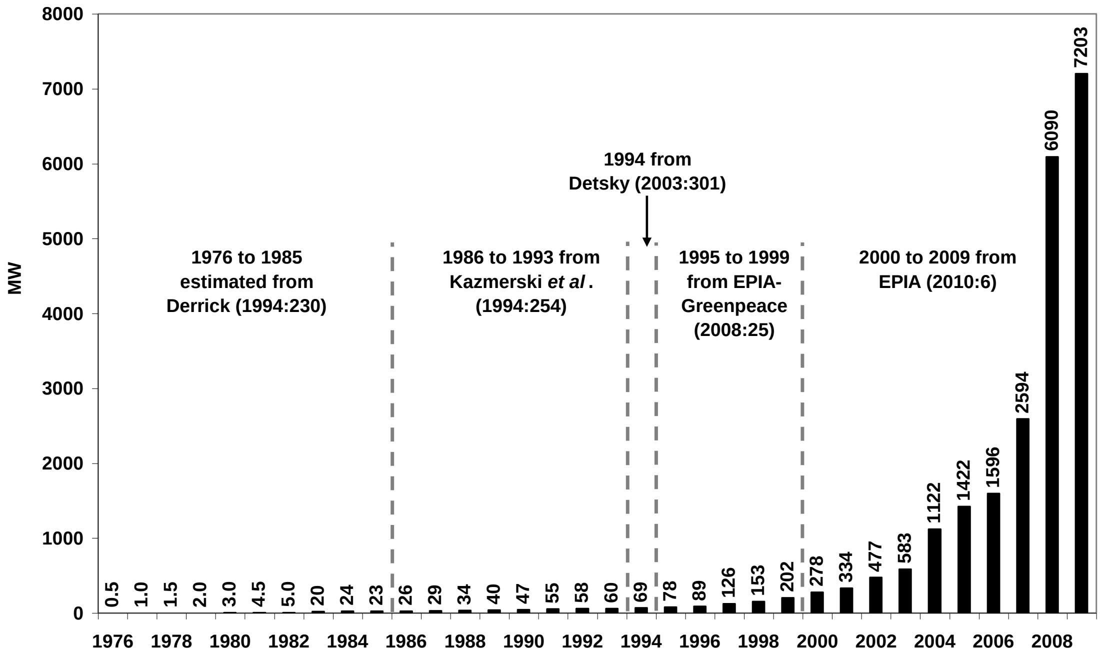

Figure 4.6: Annual worldwide PV market in MW, 1976 to 2009

The discussion in this section has sketched some of the details of the global PV niche and its development since the mid 1970s of a largely R&D focused activity to a now rapidly growing world market. Although we have seen in this some of the interest to exploit applications for PV in developing countries, we now turn to a more specific discussion of international attempts to bring renewable energy technologies to bear on the needs of developing countries. This begins with a summary of a large UN conference devoted to the issue and continues, in the subsequent section, with an account of how various efforts were grounded in Kenya and Tanzania. Taken together, these discussions help us not only to understand how PV was introduced to these countries but also why their introduction took the form that it did. And, with reference to the cost of PV and the GDP per capita values of Kenya and Tanzania, we can see at least some of the explanation for the differential levels between the two countries of adoption of PV for household electrical services. Kenya has been consistently ‘richer’ than Tanzania since the late 1980s, although not rich in an absolute sense; and PV systems seem to have been generally cheaper in Kenya compared with Tanzania (although our data for system prices are weak). Nevertheless, as we will see in the case studies, a closer examination of the efforts of actors in Kenya and Tanzania shows that there were also many nuances to the differential development of the two markets. These would be missed if we were to rely on conventional analyses of market trends and price.

The cost of PV must, of course, play a role in whether it is adopted or not but the Kenyan market was already thriving by the early 1990s when the cost of PV was still high (perhaps more than USD 30 per watt-peak for a system installed).

4.3.4 UN Conference on New and Renewable Sources of Energy

The UN Conference on New and Renewable Sources of Energy, held in Nairobi in August 1981, was an international attempt to begin solving the problem of the energy transition away from oil, particularly focusing on the developing world. The conference attracted around 3,000 delegates, including the prime ministers of some countries. During the preceding two to three years, the preparations had produced many studies on energy technologies, focusing on the extent to which they were ready to be exploited in the pursuit of development. The conference itself included discussions of 14 different sources of energy, based on a synthesis report of the various studies. However, Barnett (1981:1-1a), reporting on a meeting to discuss the synthesis report, provided a critique of, among other things, the technology transfer problems that were not addressed. The technology transfer challenge had, according to this view, three aspects: first, the broader context of technology transfer; second, the local technical capacity regarding "the energy problem" and potential solutions; and, third, the location of research in close proximity to users.

Indeed, it seems that one of the more contentious issues was technology transfer and whether there would be any new institutions or money for the process. Eckholm (1981) notes that the Secretary-General of the conference, Enrique Iglesias, "avoided calling for grandiose institutions or funds that the rich countries would be in no mood to bankroll", although he did make a somewhat oblique plea for such in a paper published in the summer of 1981 in the OPEC Review (Iglesias 1981:18). But the US delegation led opposition to creating new multilateral institutions for technology transfer based, it would seem, on the market-ideology preferred under the new Reagan Administration. The developing countries were keen to establish such an institution, but the US view was that financing for technology transfer would come primarily from the private sector or, possibly, through bilateral assistance (Tinker 1981). The finer points of the technology transfer process only received a few mentions in the report of the conference. Echoing Barnett's (1981) comments, Biswas (1983:124, citing Bradford Morse[20] of the UN Development Programme – UNDP) writes:

> While much research [into new and renewable energy technologies] is going forward in advanced countries where the state of the art continues to improve steadily, the problem of selecting, acquiring, adapting and applying this research to the needs of low-income countries remains critical and a satisfactory mechanism to solve it has not yet been found.

And, also in the report, El-Hinnawi, Biswas and Biswas (1983:25) write:

> Those [new and renewable energy] technologies that have a modular character have inherent technical, social, economic and political advantages, and can be of great benefit to the rural populations of developing countries by virtue of their potential for delivering energy within reasonable lead times.
>
> The potential for development and use of these technologies at the desired level exists in both developed and developing countries. However, there are difficulties associated with their "newness" which may [require] appropriate effort to assimilate them into the social and cultural life.

In terms of the discussions about technology options, the applications identified for PV were almost entirely for community services and commercial enterprise. Energy at the household level in developing countries was considered to be an issue of biomass and kerosene supply and use; household electrification in the rural areas of developing countries did not get much attention.

The conference ended with an agreed programme of action but, with no funding and no institution to oversee the implementation of the programme, it was difficult to make any progress. Instead, a committee was formed and this began meeting soon after, and for many years (Arungu-Olende 2008). The committee managed to publish information and studies regarding renewable energies, but it is unclear whether they were able to achieve any more than this. Nevertheless, the conference was, reportedly, an exhilarating experience for those who attended. For many, it was the first time to meet so many others working in the renewable energy field, and to see examples of a wide array of renewable energy technologies. In Bess' (2002:1) words, "[t]here was excitement in the air, a feeling that the world was embarking upon a new path towards sustainable development".

[20] Morse was the Administrator of UNDP.

4.3.5 PV for community and commercial services

Prior to the UN conference in 1981, it seems that PV was already in use in Kenya for some limited applications (and perhaps Tanzania[21] but there is no documentation), although it is difficult to establish exactly what these applications were, and when, and by whom, the systems were installed. According to Hankins and Bess (1994:2), and Duke, Jacobson and Kammen (2002:481), these early systems were for powering telecommunications, although it is not clear whether they were commercial, funded by donors, or whether the Kenyan Government was involved in some way. The Kenyan National Paper for the 1981 UN conference simply states that PV had “barely been tried in Kenya” (Mugalo 1981:10). Whatever the precise details, it seems that supply and installation in the Kenyan PV sector, to the extent that they existed, were dominated by international telecommunications companies and that “all the PV components used including the wiring accessories were imported” (Masakhwe 1993:66).

The initial experiments with systems in Kenya, for which ‘hard data’ are available, were with clinic and vaccine refrigerator systems (Roberts and Ratajczak 1989; McNelis, Derrick and Starr 1988). The first two of these systems (clinics) were installed in Kenya in May 1983, one each in the villages Ikutha and Kibwezi (Roberts and Ratajczak 1989:15, Table II). In September 1984 and January 1985, a total of three vaccine refrigerator systems were installed (McNelis *et al*. 1988:43, Table 4.3), although no locations are given. The two clinic systems were funded by USAID, used equipment manufactured by Solarex (a US company), and were designed and installed by staff from NASA-LeRC (NASA Lewis Research Center) (Roberts and Ratajczak 1989). The three vaccine refrigerator systems were funded through the WHO-EPI (World Health Organization Expanded Programme on Immunization) effort and used BP Solar-LEC equipment (McNelis *et al*. 1988). The objective of the USAID clinic project was (Roberts and Ratajczak 1989:16, Table III):

> … to increase health services in rural areas by demonstrating applicability of PV power systems for rural clinics by providing electricity for vaccine storage, lighting and other discretionary uses; e.g., dental equipment, communications, staff residential lighting and water pumping.

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[21] There was early interest in PV in Tanzania. A workshop to discuss various solar energy technologies took place in Dar es Salaam in 1977 (UTAFITI 1978).

These projects were part of much larger programmes of experimentation with PV systems in developing countries. During the period January 1983 to October 1984, systems of various kinds were installed by NASA-LeRC in nine sub-Saharan African countries: Burkina Faso, Gabon, The Gambia, Ivory Coast, Kenya, Liberia, Mali, Zaire and Zimbabwe (Roberts and Ratajczak 1989:15, Table II). The types of systems installed were: rural clinics, vaccine refrigerators, school lighting and TV/VCR, water pumping, and outdoor lighting (Roberts and Ratajczak 1989:14, Table I). A further six vaccine refrigerators in total were installed in three countries (Ghana, Kenya and Tanzania) through WHO-EPI between May 1984 and January 1985 (McNelis *et al*. 1988:43, Table 4.3). And, prior to these, OXFAM had supplied 52 PV-powered pumping systems to Somali refugee camps in 1980 (Hankins and Bess 1994:2). The WHO Expanded Programme on Immunization had the highly ambitious goal of immunising[22] "all children of the world by 1990" (Henderson 1989:46). Part of this effort was to strengthen the cold chain, hence the interest in PV-powered vaccine refrigerators: field tests suggested they were more reliable than kerosene-fuelled types and were cheaper under certain conditions (McNelis *et al*. 1988:45-47). By the mid 1980s, the programme included a commitment "to adopt PV-powered refrigerators wherever they were economically and technically justified" (Foley 1995:12).

Perhaps as a direct response to this donor-funded activity, and in anticipation of the future PV markets in developing countries, a few companies set up offices or agents in Kenya and Tanzania during the early 1980s. Certainly, some of the market projections at the time would excite significant business interest. For example, a study for the European Commission reported estimates of market *potential* of different PV applications in developing countries at: 50 million small solar water pumps, 5000 vaccine refrigerators per year, and a total village power potential of 3.75 TWp (Starr and Palz 1983:121). Animatics, an agricultural equipment supplier in Kenya, started supplying ARCO modules as early as 1981, selling a reported 420 modules that year (Hankins 1990:62, Table 4.1). BP Solar set up an office in Nairobi, or possibly established Securicor as their agent, in 1983 (EAA 1998:23). Total Solar entered the market in late 1985 (Hankins 1990:67), although they may have been concentrating on establishing a network of dealers for the first year (Rioba 2008); indeed, EAA (1998:25)

[22] The programme provides vaccines against BCG, DPT (diphtheria, pertussis, or whooping cough, and tetanus), polio and measles (Henderson 1989:46, Figure 1).

state that Total became “active” in 1987. Telesales, a retailer, may have entered the market in 1985 as well (EAA 1998:24), although Abdulla (2008) claims that they had been stocking modules since the late 1970s. And Alpa Nguvu entered the market around 1986 (Hankins 1990:60). In Tanzania, TROSS (Tropical Solar Systems) had set up in Arusha around 1983 or 1984 (Arkesteijn 2000:23; Mbise 2002:7; Kitutu 2008), BP were in Dar es Salaam by the end of the 1980s or perhaps earlier (Kimambo 2008; Mbise 2002:7; Mwera 2008), and Intertec were also in Dar es Salaam (Sawe 1989:7).

It is unclear the extent to which the Kenyan and Tanzanian ministries responsible for energy were aware of these various developments. Both countries had a ministry for energy of some kind by the early to mid 1980s. As was mentioned above in section 4.3.1, the Kenyan MOE (Ministry of Energy) was formed in 1979. The Tanzanian MWE (Ministry of Water and Energy) existed prior to this but the energy section may have been quite inactive until the mid 1980s (Sawe 2008). We know that, also around the mid 1980s, the Italian Government donated some PV equipment to Kenya, including a water pumping system and energy research laboratory (Rioba 2008). MOE in Kenya created a biomass department around 1984 (Arungu-Olende 2008), which eventually became a renewable energy department in 1998; and MWEM in Tanzania (the ministry gained ‘minerals’ at some point) created a renewable energy section around the same time (Sawe 2008). The first Kenyan Energy Policy was written in 1987 but it remained an internal document (ROK 1987); while the first Tanzanian policy was published in 1992 (URT 1992). While both ministries were engaged in renewable energy projects, and both policies at least mentioned PV, there is no evidence that they were particularly active with the technology (Rioba 2008; Sawe 2008). For the most part, as the findings reported in section 4.3.1 above would suggest, the ministries (and donors) were more concerned with finding solutions to the problems around biomass energy.

So, in the early 1980s, there was no significant market in either Kenya or Tanzania for household PV systems. Projects for commercial and community services systems continued and so a market developed around these. Indeed, these kinds of projects have continued up to the present, and they account for a large part of the installed capacity of PV systems in the region (ESD 2003).

4.3.6 Analysis of PV for community and commercial services

The particular form of this early PV socio-technical trajectory in Kenya and Tanzania – community and commercial services PV systems – appears to have been influenced by a number of forces acting at different levels. At the landscape level, there were the competing development paradigms (Hunt 1989) of the basic needs approach and neo-classical economics. These forces were felt acutely within the development organisations, particularly within USAID, where policies and programmes were being formulated that were accountable to domestic political actors who favoured one or other of these development perspectives. This was a clear tension within the US part of the development regime; perhaps also within some European development organisations. Moreover, the policy and programmatic response needed to relieve this tension was further complicated by the increasingly apparent 'energy problem'.

At the regime[23] level, that energy problem started to become apparent when the assumption of economic growth fuelled by cheap oil was seriously challenged by the actions of OPEC in 1973, helping to create an expectation of a future economic system based on energy carriers other than fossil fuels: in other words, a second-order kind of learning. There was already something of an international PV niche, developed around the space programme and a few specialist applications; and the US had some manufacturing base for it. Significant US federal resources were targeted at R&D into PV technologies, perhaps in the hope of exploiting a comparative advantage gained out of the space programme. In any case, these experiments enabled a process of first-order learning that sharpened the initial expectation of an economy driven without oil into a more specific and detailed vision of how this could be achieved, at least where electricity-generation was concerned. A number of product and production innovations came out of this first-order learning, as did process innovations such as design, installation, monitoring and maintenance practices. Economic analyses provided the basis for constructing learning curves, and for conducting market analyses; the results of which helped identify where PV could be applied immediately and where and when it would likely be applied next. These various data and developments then formed the basis on which arguments could be made to recruit resources for field experiments.

[23] This does not refer to a specific regime; rather, it refers to the level of regimes in a more general sense – governmental actors, and institutions and systems by which energy services were realised both nationally and globally.

The period of reflection created by the rise of the basic needs paradigm saw development assumptions being explicitly and deliberately challenged: a purposive kind of second-order learning. Rural electrification was seriously examined, initially, as to its role in meeting basic needs and, subsequently, as to whether it had any development impact whatsoever. For USAID, the outcome of these debates – the first-order learning – pointed to interventions where public goods were clearly identifiable (health, education, and so on) and where the supply of electricity for productive uses (agriculture, business, and so on) could be based on what were still experimental technologies. Both these kinds of interventions could be justified within the constraints of the basic needs approach and, to some extent, the neo-classical paradigm.

There was further second-order learning stimulated by the household energy studies conducted in developing countries. Little was known about energy-use at the household level in rural areas or, at least, few people outside of the cultures that were practising these energy-use patterns. Consequently, for many, the results of these studies provided a new expectation-vision simultaneously. Even for those familiar with the practices, the detail of the studies articulated their own expectations: the extent to which cooking, for example, consumed energy compared with other tasks. The outcome of this learning, having been widely collectivised, was to direct resources towards solving the energy problem of unsustainable biomass use in households. In Kenya, this saw the creation of a new technological artefact, the Kenya Ceramic Jiko.

As for PV, it is clear that any experiments with the technology, given the learning that had occurred around household energy-use in rural areas of developing countries, and the conflicting forces at play on USAID – the first donor to implement a PV project in Kenya, if not Tanzania – would not be focused on the household. Moreover, the collectivising of expectations that took place at the Nairobi conference and through the various reports and debates about rural electrification was overwhelmingly about community and commercial services systems. So, as we observed above at the opening of this sub-section, the form of the early PV socio-technical trajectory in Kenya and Tanzania was the outcome of a number of forces, expectations, and learning operating at various socio-technical levels. This helped to bring the technology into the region, making it more accessible to the actors who subsequently developed household markets and a regional PV niche.

4.4 Summary of the chapter

This chapter attempted to provide a sketch of the context of our case studies, which are examined in the next two chapters. We discussed landscape and regime factors in the form of development paradigms, development regimes, and the political economies of Kenya and Tanzania since their independence. We then considered the way in which rural energy needs in developing countries came to be better understood through early studies. These revealed that biomass was the most important energy carrier for the vast majority of people in developing countries; something that was not fully appreciated by many before the studies were conducted. The results focused the attention of many in the development regime on trying to solve what was conceived to be the ‘other energy crisis’. Nevertheless, development regime actors such as USAID were keen to continue supporting rural electrification projects and attempted to find ways to do so while constrained by two opposing development paradigms: the basic needs approach and neo-classical economics. One way to resolve this tension was to focus electrification projects on public goods. Other actors working through the international development regime, such as the UN, came to similar conclusions when considering how expensive renewable energy technologies could be used in development interventions. When this thinking was grounded in projects in developing countries, the result was to install community and commercial services PV systems. This was certainly the case in Kenya and Tanzania. With expectations of large markets for such systems, international PV suppliers were attracted to the region in order to exploit a potentially rich business opportunity. PV technology was now available in East Africa and this afforded opportunities for others to experiment with it outside of the project market. The next chapter explores how this experimentation led soon after to a market in household PV systems. Chapter six explores how such a market did eventually materialise in Tanzania but much later than was the case in Kenya.

5 The Kenyan Case Study

5.1 Introduction to the chapter

We saw in the preceding chapter how PV came to be in East Africa through donor-funded community services projects. This chapter begins with the emergence of a household market in Kenya. Following this, we discuss how the household market potential began to be exploited and that the idea was picked up by other companies. By the time Mark Hankins did his MSc research, there was an active market in household PV systems. He set about disseminating this and recruiting others to a broadening network. Eventually, he had the chance to do more substantial projects and started his own company – EAA – to exploit the opportunities. The chapter goes on to describe and analyse a number of the niche developments that took place as the market grew in Kenya. Eventually, in the early part of the 2000s, niche actors were interacting with the policy regime directly as they attempted to influence Kenya's new energy policy. The chapter finishes with a discussion of this process.

5.2 An emergent trajectory

This section describes and analyses the very early period of the household market in Kenya; how it emerged and how it was initially developed. These activities attracted others and, as we will see in subsequent sections, the initial work had a lasting effect on the PV niche in Kenya.

5.2.1 Discovery of a household market

The private market in household PV systems is said to have started during 1984 and its beginning is attributed to the activities of Harold Burris, an ex-Peace Corps volunteer, after he set up the company Solar Shamba[24] in a coffee growing region south of Mount Kenya (Acker and Kammen 1996:87; Duke *et al*. 2002:481). Burris was an engineer by profession and, according to one obituary, had worked in the nascent US solar industry (SolarNet 2001:8), particularly with Texas Instruments (Hankins 2007), before coming to Kenya with the Peace Corps in 1977 (Perlin 1999:132). He was, according to

[24] "Shamba" is a Swahili word that can be translated to mean "farm", although it can be used for anything from a plantation to a small plot of cultivated land; and it also has connotations of "rural" (Johnson 1939:416).

Hankins (2007), politically radical and fiercely independent, and so found it difficult to work within the constraints of traditional organisational hierarchies. As a result, he tended to not keep a job for very long before either resigning or being dismissed; indeed, according to Hankins, he was dismissed from his Peace Corps assignment, following which he returned to the US where he did some "early computer-circuit work and helped to develop a health device for a friend", which made him enough money to return to Kenya, around 1979, with his own resources (Hankins 2007). After spending some time in Mombasa with his wife, Stella, the couple moved to Yata (Stella's home town) in Machakos where Burris began working with appropriate technologies and became "well-connected with AT people" there (Hankins 2007). He attended the UN conference in 1981 where it is likely, according to Hankins, that he used the opportunity to network extensively. In 1982, Burris set up Kidogo[25] Systems (Jacobson 2004:125n160) and tried, unsuccessfully, to market a PV-powered sewing machine through the Singer Company (Hankins 1993:31; Perlin 1999:133). He had developed the idea for his wife, a seamstress, powering her sewing machine by PV "from day one" (Hankins 2007). While Hankins (1993:31) seems to attribute the failure of this project to an abortive coup in Kenya in 1982, he now says it failed because the machine was far too expensive for the Kenyan market (Hankins 2007). Nevertheless, the episode indicates that Burris was searching for a means to earn a living in Kenya, that he was able to source PV equipment, and that he was experimenting with PV systems.

Some time around the middle of 1983, Burris met Mark Hankins by chance at a café in Nairobi (Hankins 2007). Hankins was a Peace Corps volunteer teaching science at Karamugi Harambee[26] Secondary School, which was in the process of considering electrification with a "used 5 kVA diesel generator" (Hankins 1993:31). The generator was chosen because the cost of connecting to the grid, some four miles away, would have been about USD 21,000 (Perlin 1999:133). When Hankins mentioned this in their conversation, Burris suggested that he could install a PV system instead. Hankins was

[25] "Kidogo" is a Swahili word that can be translated as "small" (Johnson 1939:76, see the entry -*dogo*).
[26] "Harambee" is used in Kenya to mean "self-help", and is the national motto (Barkan 1994:19). "… Harambee, or self-help, is a pervasive movement that has become a major arena of rural politics and has shaped the structure of peasant-state relations in that country. With its fifteen to twenty thousand community development organizations scattered across rural Kenya, this self-help movement engages just about all rural dwellers, most politicians, and many state personnel. The primary activity of these organizations is the construction of social-service infrastructure by the residents of rural communities in order to meet their locally defined needs. … nursery, primary, and secondary schools, village polytechnics, cattle dips, health centres, water projects, etc." (Barkan and Holmquist 1989:359-360).

unconvinced – "I didn't trust Harry at all; the guy didn't look serious" (Hankins 2007) – but he nevertheless put together a comparative cost analysis for the board of governors showing that PV would be cheaper than the diesel generator (Perlin 1999:133). The board was also un-persuaded but agreed to visit Burris' home system, after which they were impressed enough to postpone purchase of the diesel generator and to trial the use of PV in four classrooms and the headmaster's office (Hankins 1993:31-32; Perlin 1999:133; Hankins 2007). The lighting system Burris designed cost the school USD 2000, which "was less than the first cost of [the second-hand] generator" (Hankins 1993:32). Hankins (2007) recalls that Burris was struggling financially at this time; that "he was very desperate, he was broke": the modules he used for the Karamugi installation were left over from his failed sewing machine project. Once the school had given the go-ahead for the installation, Burris went to work on the BOS (balance-of-system) components: charge regulator[27], 24 VDC lights from a local manufacturer, local car batteries, module mount, and battery boxes (Hankins 2007). Hankins (2001:2) elaborates on which of the BOS components Burris put together himself and which he sourced locally:

> He [Burris] found that ballasts for 12VDC lamps were being manufactured for local buses by Nairobi company, Sound Communications. Further, he designed and assembled basic charge regulators and DC-DC converters (which allowed use of radios and cassette players) in his own shop. Further, he coaxed the local battery company to improve the design of their automotive battery to make it more suitable for PV systems. He designed module mounting systems and other balance of system components that could be made cheaply and by cottage industry groups.

During the Karamugi installation, which took place sometime during the first to third quarter of 1984 (Hankins 2007), "Burris used the services of an electrician based in the town near Karamugi and he trained the school's lab technician to monitor and maintain the system" (Hankins 1993:32). The results of this monitoring were "fed back to the installers" (Kimani and Hankins 1993:93).

According to Hankins (1993:32), and Kimani and Hankins (1993:93), the headmaster, some of the teachers and others in the community bought systems for their own homes

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[27] Although Hankins describes this as a charge *regulator*, it is likely that the device was actually a change *indicator*, as Burris used such self-designed indicators in later installations (Hankins 1990; Hankins 1993:35).

"within six months of the school's installation". This was a clear signal to both Burris and Hankins that there could be a market for household PV systems: Burris "saw that there was a lot of business and there was a coffee boom[28] going on too so there was a lot of cash" (Hankins 2007). A major factor in the demand for electricity is the desire to watch television, and portable DC TVs began to appear on the market in about 1981, with the TV signal being broadcast to more and more rural areas during the 1980s (Jacobson 2004:150-157, and Figures 24 and 26; Hankins 2007). In response to these developments, Burris moved to Embu where he renamed his business Solar Shamba (Jacobson 2004:125n160). Hankins, for his part, was already applying to Peace Corps by the second quarter of 1984 for an independent placement in which he would work with Burris on a project to install PV systems in three more schools, and include in the package the training of local technicians (Hankins 2007). According to Hankins (1999:6), he and Burris believed the training element would be critical to the growth of PV applications in Kenya; that rural electricians would need to be able to "sell, install and maintain PV systems".

In Embu, as he had done in Meru, Burris powered his home and workshop with PV (Perlin 1999:133): "He was in town but off-grid. … a kind of in-town appropriate technology demonstration" (Hankins 2007). He now began "to get heavily into the marketing" (Hankins 2007). Dickson Muchiri, who worked as a sales technician for Burris from about 1986 until moving to the company Alpa Nguvu in 1987/1988, elaborates on the marketing strategies that Burris had developed by that time (Muchiri 2008):

- Writing proposals for organisations looking to get a PV system funded by a donor: if the proposal were successful then Burris would most likely get the job.
- Placing some kind of "working sample" in a strategic location such as a small shop: customers could see it, know that it is working, ask questions, etc.

[28] The "coffee boom" is actually said to have occurred during the period 1975/1976 to 1978/1979 (Bevan *et al*. 1990:359; Akiyama 1987:6 and 8). As Figure 2 shows, there was a peak in the value of coffee exports in 1977 following which the value fell back below USD 300 million as of 1980, remained quite steady, and then peaked at a similar level to the 1977 value in 1986. Bevan *et al*. (1990:359, citing an earlier study of theirs: Bevan *et al*. 1987) state that coffee producers in Kenya, unlike those in other coffee-exporting countries at the time, received significant earnings from the boom because "export taxes were negligible".

- Sometimes advertising in local newsletters (although not really in newspapers): there was one that went around in Embu town, for example.
- Participating in dissemination events organised by aid organisations: he could explain about solar.
- Attending district shows: one example was a show in Embu in 1986 that Muchiri believes achieved wide publicity for Burris. Indeed, van der Plas and Hankins (1998:301) note that "agricultural fairs were an important information channel in the late 1980s and early 1990s".
- Using his technicians to cold-call. He employed six permanent and two casual technicians and whenever they were installing a system in a house they were instructed to go around the area looking for potential customers: for example, if they saw someone was building a new house then that person could be a customer. And Hankins (2001:2) reports that Burris "encouraged these technicians to seek customers among the high-income households on the southern and eastern sides of Mt Kenya".

Hankins (2007) adds that Burris produced one-page mimeographs, although he does not describe the content of these. We might reasonably assume that these would, at the very least, explain what PV could power and how to contact Solar Shamba in order to buy a system.

By the third quarter of 1984, Peace Corps had given approval for Hankins' independent placement, providing he concentrate solely on the solar project with Burris (Hankins 2007). Although Hankins (2007) says that he had to convince the Peace Corps to approve the independent placement, it seems this was helped by them visiting the Karamugi installation:

> The Karamugi installation was a coup: it involved some Peace Corps leaders coming to the school and talking about how this was a great thing. So there was definitely a sense that this was a great idea and so let's talk to the people in USAID about it.

USAID could be expected to be favourable to the idea as they had already funded a "very successful" energy project in Kenya in 1984 – the Kenya Renewable Energy Development Project – which saw the creation of the Kenya ceramic jiko, an improved small stove[29] consisting of a metal case with a ceramic lining (Hankins 2007). Still, Hankins (2007) says:

> I had to write a proposal and design the training and get Harry to go in on this … . Harry was the guy who was dealing with the American companies so Harry was going to get paid to bring that equipment in. … I had to locate three schools. I did a survey of twelve schools; riding around on a bicycle on the eastern side of Mount Kenya convincing schools to put in 50% of the cost. … I did energy audits of the schools; looked at how much wood they were using and tried to come up with a case.
>
> Harry was intimately involved in the process: we would meet in Nairobi in a cheap hotel and we would work on Harry's World War Two typewriter and we would do cut and paste as we designed manuals. We also had to identify twelve solar technicians. One was a relative of Harry's wife, Daniel Kithokoi. We got the equipment, identified the schools and we did the installations one after the other [during 1985 and into 1986]. … When we trained the twelve guys, he [Burris] immediately went to all the twelve guys and said be my agent.

As mentioned above (Muchiri 2008), Burris did employ some of the technicians: six permanent and two casual. By this time, according to EAA (1998:24-26), Telesales, Alpa Nguvu Solar Systems, and ABM (Chloride) had all entered the PV market – ABM (Associated Battery Manufacturers) being the "local battery manufacturer" that Burris had "coaxed" into improving their automotive battery (Hankins 2001:2), getting the product on the market in 1985 (Hankins 1990:74; Acker and Kammen 1996:88). At the end of the USAID-supported schools project, Hankins and Burris organised a cocktail party in Nairobi so that the technicians could meet these PV and equipment suppliers, resulting in some of the technicians either being employed immediately (Hankins 1993:32) or striking deals with the companies, independently of Burris (Hankins 2007).

5.2.2 Analysis of the discovery of a household market

The Karamugi project

The evidence suggests that, prior to the Karamugi installation, Burris had not considered PV systems for households as a viable business opportunity. This was despite his using PV for his own home. However, it is clear that he was considering ways to make use of his knowledge of PV to develop a business and had tried to market at least one product: the PV-powered sewing machine. This had failed because it was too expensive

[29] The payback time was about two months and there were an estimated 125,000 stoves sold by the middle of 1985 (Jones 1986:18).

compared with the foot-powered device that was already widely available and in use. Even the process of securing the Karamugi installation was a protracted episode: he had failed to convince Hankins, who in turn had failed to convince the Board of Governors, despite having provided a favourable cost comparison with the proposed diesel generator. It was only after the Board had seen the system at Burris' home and workshop that they accepted PV as a possibility.

We can interpret this slow acceptance by the Karamugi Board quite straightforwardly. PV was a new technology and so it is unlikely that any of the Board members would have seen it in operation before the visit to Burris' home. The other ways of getting electricity – the grid or diesel generator – were already somewhat familiar. This would have made PV seem highly risky or, at least, unproven. Indeed, they may not have had any conception of PV. Seeing a system in operation would have demonstrated its functionality and may have instilled some confidence that Burris was someone who could perform the installation competently. Certainly, the Governors were now willing enough to take the risk. If second-order learning is characterised by changed assumptions then we could say that the Governors experienced such learning because they now included PV as a possible source of electrical services, alongside the grid and diesel generators. Whether this was a change of assumptions or not we can certainly claim that they were able to form a detailed socio-technical vision: a well articulated cognitive schema of PV-generated electricity services. Moreover, that vision was now grounded in a physical reality that was close to their personal experiences.

Once the system was in use in Karamugi, further learning occurred that we can most likely categorise as first-order. Obviously, there would have been much learning about the operation, maintenance and monitoring of the system: clearly learning of a first-order quality. But there would also have been the issue of confidence in the technology. For some, this confidence grew quickly and was strong enough that they were willing to buy systems for their own homes.

From the point of view of Burris, witnessing the impact his home system had on the decision making of the Board may have been an important experience that contributed to his later marketing strategies. Despite his having supplied the Board with a quantitative assessment of the costs of a PV system compared with a diesel generator (assuming that he had at least some hand in this as Hankins would have had to get information about a PV system from someone), the decision to buy a system was not made until the Board had actually seen one in operation. Of course, the visit to Burris' system suggests that the cost-comparison had raised their interest to some extent. But the 'deal-maker' seems to have been the system visit. This deal-making quality of demonstrations was reinforced by the Karamugi installation itself, when the headmaster and others ordered systems for their homes, and other schools became interested. Hankins, if it not happened already, was also convinced by the Karamugi installation[30] and was inspired to work with Burris on another project, this time much larger. Further, it was now clear that a household market in PV systems was a realistic possibility.

We can infer from these events that learning of various kinds occurred. Burris was certainly engaged in first-order learning in terms of the technical details of the systems: he had spent effort putting together the BOS components, and he was receiving information on the performance of the Karamugi system. But we can also infer some second-order learning for Burris regarding the possibility of a household market. He had not tried to market household systems, as far as we know, even though he knew from personal experience that they were technically feasible. One explanation of this is that he assumed there was no market. However, once a demand was demonstrated to him, "he mobilised very quickly" (Hankins 2007). He already had a well-articulated technical vision of PV; most likely an economic one; a social dimension (in that he used the technology in his own home); and now he was able to add a business or market aspect. He was yet to develop the detail of this market aspect, and how to sell to it, but he had a beginning: there were wealthy enough customers in rural areas who, if they saw the technology in operation, would buy systems for their homes.

Hankins was also recruited to this vision, albeit with his own dimension to it, having now learned that PV was viable and that there was a potential market for PV systems. He could also now see that Burris was "serious". Hankins' version of a socio-technical vision included a training aspect. Between them, they had constructed a basic strategy to capitalise on this nascent market: Burris would address the technical aspects while developing his business; Hankins would address the training. This would be more

[30] Hankins was not present when the Governors visited Burris' system (Hankins 2007).

straightforward for Burris in that he could concentrate on finding customers, some of whom were already coming to him. It would have been more problematic for Hankins as he would be unable to sell training in the private sector. So, the notion of implementing a donor-funded project that included training would have seemed sensible. Such a project could be expected to replicate the experience of Karamugi: demonstrate the technology to generate interest and then hope customers would emerge.

Hankins was able to recruit relevant people within the Peace Corps to this vision, themselves having been influenced by seeing the system at Karamugi. Again, the demonstration effect was evident. However, the proposed three-schools project was also in line with existing Peace Corps interests. They had been working since 1979, with financial support from USAID, on developing a rural energy survey methodology, which was "one component of a Renewable Energy Program … to assist developing countries in identifying energy needs in rural areas and in implementing alternative, renewable energy projects at the community level" (Peace Corps 1984:vii). So, from the Peace Corps perspective, the Karamugi installation was exemplary and it is easy to see that they would support similar projects, assuming some due process such as a project proposal, and so on. Indeed, the proposed project would be strengthened, in the Peace Corps view, by a much larger and more systematic training element. This training aspect was also in line with the development regime's interest of building capacity in the private sector.

We can see network-building happening during the Karamugi episode. Burris was already involved in an appropriate technology network in Kenya and knew the PV suppliers, while Hankins was involved in the Peace Corps network and was working in Karamugi School. Karamugi was deeply embedded in its community, especially considering it was a Harambee school, and there would have been some connections to other schools at least because of the education system. Both the school and the Peace Corps, of course, had access to financial resources: the school directly from the community; the Peace Corps from USAID.

The three-schools project

The processes associated with the three-schools project were sites of further learning, and forming and refining of socio-technical visions; there was also network-building, institutional innovation, and the mobilising of resources. For Hankins, the three-schools project was significant because it resulted in a model of PV market development that he would later use in Tanzania, as well as much of the material he would use to write what became a textbook of PV system installation tailored to an African context. For Burris, apart from the immediate benefits of paid work and the potential of more to come, the project was important because he was able to train his own agents (as many of them became) at no cost to himself. For the technicians who were trained, the project provided an opportunity to develop new skills and knowledge, to get work and to connect with the PV suppliers in Nairobi. The suppliers themselves benefited by gaining access to more trained technicians. The schools, of course, benefited from subsidised PV systems and the electrical services these afforded. And, in terms of a *local* PV niche, the project was important because it demonstrated that PV could be installed by Kenyan technicians; that it did not require highly paid foreign specialists.

We can identify important first-order learning in Hankins' energy audits, which he conducted during his survey of twelve schools. These audits would have helped to quantify aspects of the case he was building to persuade schools to come into the project. The learning here involved developing an energy survey methodology and more precise information on the costs (in time and effort as well as money) of using various energy carriers compared with electricity generated using PV systems. The most direct comparisons would have been with kerosene for lighting; and dry cells, fuel-generators or grid connections for electricity. Indeed, Hankins provides cost-comparison examples of all these, except grid connections, in the 1995 edition of his book *Solar Electric Systems for Africa* (Hankins 1995:109-112). Not only would these cost-comparisons have been useful in persuading schools to come into the USAID-supported project, they would have helped form the basis for future arguments related to the costs of PV elsewhere, as well as further articulating a PV socio-technical vision.

PV systems were further indigenised through the project. In terms of technical artefacts, there was a number of innovations. Burris was continuing to refine the technology as much as he could, and he persuaded ABM to modify their automotive battery so that it better suited the needs of PV. He worked with others to develop his manually rotatable module mount, which enabled significantly more solar energy to be harvested by a PV system. This was developed with the help of a local NGO. The ballasts for DC lamps were available locally, Burris made his own charge regulators and indicators, and reflectors for the lamps were made locally, as were battery boxes. Clearly, the training of technicians was a significant indigenising process. They were trained in the design, installation, operation and maintenance of systems. Those who worked for Burris would also have been trained in making charge regulators and the other components he developed. And, of course, they would have been active in developing the marketing strategies used by Solar Shamba.

Training, by definition, is about developing practice: that is, an important element of institutional embedding. The design of a system begins with understanding the energy needs of the customer. Here, Burris developed various forms for recording information about a householder’s electricity needs and these were tailored to the kinds of homes that were most likely to be found in rural Kenya. The evidence of these appears much later but Burris, as has been said elsewhere, was strict about adherence to good technical practice so we can assume that he was using these information gathering methods from the outset. The design itself involves sizing calculations and Burris developed simple processes for this, which would have been part of the training in the project. These sizing procedures certainly appear in Hankins’ 1995 book. Installation involves a number of processes that would have been familiar to electricians but there are also procedures that are more specific to PV systems. For example, the commissioning of a battery: filling with electrolyte; its first charge; what to do if there is spillage of the electrolyte; and so on. In operation, a PV system is straightforward but it does better if a few simple energy-saving habits are cultivated, and the information supplied on the charge regulator is understood and its implications addressed. For example, if the regulator or indicator shows the battery charge to be low then it is better not to use the loads until the charge returns to a high level again. The customer should be aware of these kinds of operational details and so it would have been important to include this in the training. And, finally, maintenance of a system is simple but, again, important: cleaning the module; topping up the battery; checking connections are secure; and so on. All these aspects are present in Hankins’ book and they were part of the training courses given elsewhere. So, we can see that the project was also important as an early attempt to set an institutional trajectory. These procedures had to be articulated so that they could be expressed in the training and Hankins acted as translator here between Burris and the technicians. Burris explained the technical details to Hankins who then attempted to write these in a form that the technicians could understand.

The business impact of the three-schools project was similar to the Karamugi experience. Once a system was installed in a school, there was interest stimulated among the local community and orders for systems began to flow. Here was more evidence that demonstrating the technology was a powerful marketing device. Further, as a later study showed, many people learned about PV systems and bought them as a result of seeing an example in a neighbour's house (van der Plas and Hankins 1998). As Hankins (2007) puts it: "Once someone had bought a system, he would have four or five friends come over and they would all want one too". Again, we can identify learning but not necessarily whether it is of a first or second-order quality. There is something of a first-order dimension to it in that learning that PV can supply electricity has an instrumental quality: that is, if someone wants to get access to electricity and then finds a way to do it, that is instrumental learning. Whatever the quality of the learning processes, we can certainly infer that demonstrations helped to articulate socio-technical visions: those who were working with PV systems were able to conceptualise them in, to a lesser or greater extent, precise terms, communicate these terms and hence collectivise a socio-technical vision. So, systems could be described: what they looked like; how much they cost; their functionality; their reliability; who could install them; and so on. Information in this form is much more readily transmitted in conversation enabling personal networks to act as effective communication channels.

As with users and customers being able to describe systems in more precise terms, so with supply-side actors being able to articulate more precisely the market. By installing systems in homes, Burris, the technicians and others were meeting customers and developing knowledge of who they were and what they wanted. In other words, they were able to begin articulating the market: kind of learning-by-doing market surveys. We can assume the technicians would already have had considerable knowledge of local culture, including energy use, but it may not have been articulated in any detailed sense. Faced with having to explain PV systems to customers and how they would fit into their lives, in the hope of persuading them to buy, they would likely develop this articulation to some degree. Burris, also, is likely to have had some knowledge of local culture, having already lived in Kenya for many years and been married to a Kenyan. Still, we can assume that he would have learned a great deal in his interactions with customers and this will have helped him to refine aspects of the technology as well as understand the market better. These more precise articulations would have informed marketing strategies as well as technical developments and socio-technical visions.

5.3 Development of marketing models in the household PV sector

The market began to grow quickly during 1985 and 1986, although figures for the number of systems installed are only estimates. Hankins (2007) believes there could have been about a million dollars' worth of installations *altogether* over the ensuing two years (amounting to a few thousand systems at between USD 500 and USD 1000 each), with Solar Shamba doing many of these. Other estimates for Solar Shamba range from about 150 systems (Hankins 1990:72), to "hundreds of solar home systems" (Hankins 2001:2), to more than 500 homes (Perlin 1999:135), although this last figure is taken from Hankins (1987:107) and seems to be a *total* for Kenya, as of January 1987, rather than entirely attributable to Solar Shamba. As noted above, Duffy *et al*. (1988:3-5, Table 3.1) report that there were USD 218,000 worth of PV imports from the US to Kenya in 1986. Up to and including 1986, the estimate is 82 kWp. The first year that we have an indication of module *sales* is 1987, estimated to be 88 kWp.

Prior to June 1986 there had been import duties and VAT on PV modules (Acker and Kammen 1996:92). Import duties had been at 45% but were completely removed because of lobbying, by the World Bank (Jacobson 2004;142n184) and by the private sector (Acker and Kammen 1996:92). Actually, according to Hankins and Bess (1994:7), there was no official duty rate for PV equipment prior to the 1986 "removal"; any import duties that were applied depended on an arbitrary choice by the customs official at the border. There does seem to have been confusion, at the very least, over whether duties should be applied: Muchiri (2008) states that modules would be categorised differently depending on whether they had diodes[31] attached or not.

[31] A diode is connected in series between the module and battery to prevent discharge from the battery when the module voltage is lower than the battery voltage, as would happen in darkness. Muchiri (2008)

Still, whether the imposition or removal of duties and VAT made any difference to sales is, according to Acker and Kammen (1996:92), "subject to debate". They cite two, apparently, opposing views: that of Hankins and Bess (1994) and that of Karekezi (1994). Hankins and Bess (1994:7) claim that the sales of modules "increased dramatically" but Acker and Kammen (1996:92) state that "Karekezi found … no savings were passed on to the customer". Judging by the estimates reported in Figure 5.1, we can see that sales did rise very quickly in the period 1986 to 1988 but this could have happened for reasons other than price reductions. First, sales were starting from a low base and, second, this period was the beginning of intense marketing by a number of companies.

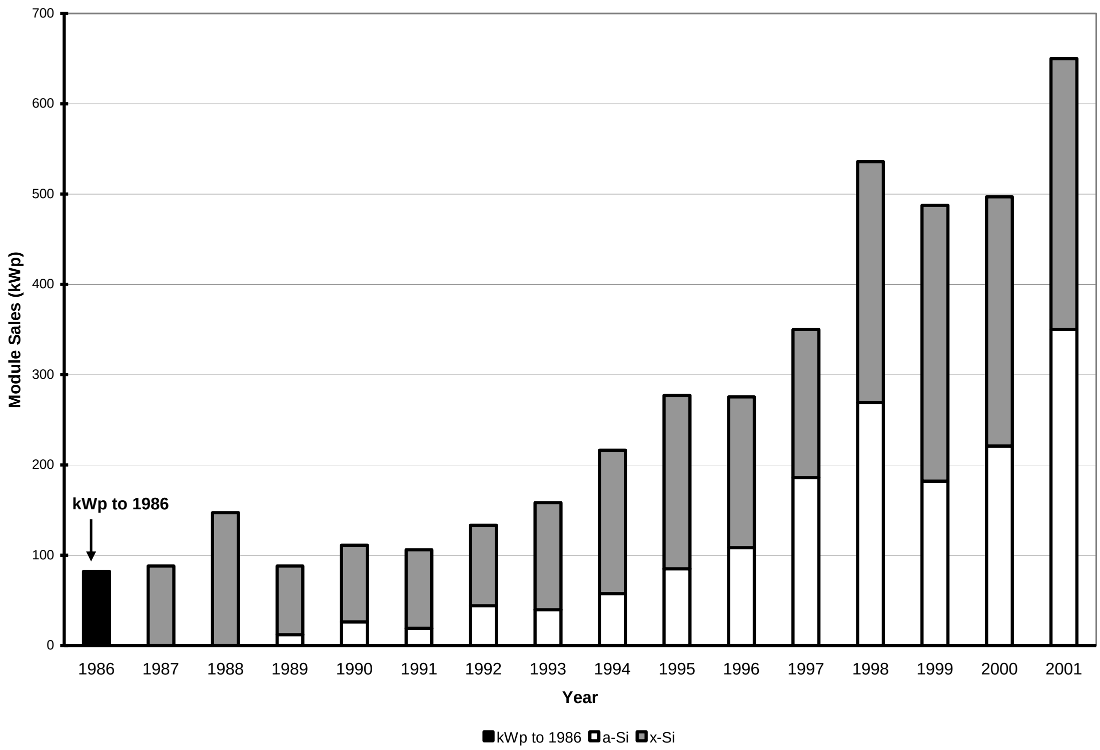

Figure 5.1: Estimated module sales (kWp) 1986 to 2001
(a-Si means amorphous silicon modules; x-Si means crystalline silicon modules)
Source: Hankins *et al*. (1997) and BCEOM *et al*. (2001)

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says that modules with attached diodes attracted duties while those without did not. In order to avoid duties, the international suppliers would be asked to send diodes separately.

5.3.1 The dealer-network approach

At least one other approach was being developed at about the same time as Burris was building his business. Charles Rioba, a chemical engineer who had worked in the Biomass Department at the Ministry of Energy and Regional Development from 1983, had become interested in solar and was looking for a way to develop his own career, the prospects for which he saw as unpromising within the ministry (Rioba 2008). He took a year out from the ministry to do a masters degree in renewable energy at the University of Reading in the UK during 1984/1985, returned to the ministry and registered his own company, Solar World, but did not yet work on it full-time. Instead, he decided that he needed more practical experience and managed to get a job with Total Solar, a subsidiary of the French petroleum company Total that had a network of outlets across Kenya.

Total were interested in selling PV in Kenya[32] and were looking to develop a business model. Rioba became their Dealer Development Manager in late 1985 (Rioba 2008). Total Solar were mainly involved in solar thermal systems but, according to Hankins (1990:67), they began to include PV in late 1985, around the time that Rioba joined them. Rioba spent his time setting up dealerships around Kenya, "trying to identify risk-takers" (Rioba 2008). Two of the marketing techniques he developed were installing subsidised demonstration systems in homes, and setting up demonstration kits in the dealership outlets. These demonstrations, according to Rioba, were the most effective for persuading people to buy systems, especially the demonstrations in homes. Total Solar were not, initially, interested in installing systems in households – they were more interested in larger systems – but household installations became a more significant part of the business over time: according to Hankins (1990:68) they installed about 50 household systems in 1986 and had installed about 550 systems by May 1990, by which time "they [preferred] to install the kit themselves using the company's trained technicians" (Hankins 1990:67). According to Rioba (2008) and Masakhwe (1993:67), Total trained their own technicians as part of the dealership package. These were short courses – about three or four days – and covered both solar thermal and electric systems

[32] Although Total were interested in selling solar equipment in Kenya (and perhaps elsewhere), Rioba characterised their motivation as a public relations exercise: that is, it was more of an attempt to look environmentally responsible than a serious attempt to develop sustainable technology markets (Rioba 2008). Nevertheless, before they started selling PV, they had about 70% of the solar hot water systems market in Kenya (Hankins 1990:67).

(Rioba 2008). Altogether, Rioba estimates that about 80 technicians were trained in this way, including Rioba himself, some of them working in the dealerships and others directly for Total Solar in Nairobi.

Masakhwe (1993:67) acknowledges the importance of Total Solar and their training, as well as their pioneering of the dealer-network approach to marketing PV. By the time of Hankins' MSc research in 1990, Total Solar had about twelve dealerships in Kenya: Kitale, Embu, Mombasa, Kisii (the dealer here being Solar World, Rioba's own company), Nanyuki, Malindi, Eldoret, Kisumu, Nyeri, Meru, Nakuru and Nairobi (Hankins 1990:67; Rioba 2008). And, by 1990, other companies had embraced the dealer approach "as most companies [could not] afford to competitively operate from Nairobi without local agents or dealers" (Hankins 1990:69). Competition in the market had been increasing and, from about 1987, the companies had begun "intensive marketing campaigns employing both the commercial media (newspapers, magazines and radio) and district agricultural fairs to advertise and demonstrate their products" (Hankins and Bess 1994:3). There were various kinds of interactions between companies. Some of these were commercial: buying modules from each other, and occasionally in quite large quantities (Hankins 1990:62, 66, 78; Rioba 2008). Other interactions were more indirect such as the movement of technicians between companies (Muchiri 2008). Muchiri, himself, is an example. He trained and worked with Burris, moved to Alpa Nguvu, spent some time freelance, and now works with Rioba at Solar World. And it is well-documented that many of Burris' other technicians went on to work with other companies or start their own businesses (Hankins 1990:72; Hankins 1993:33; Acker and Kammen 1996:87; Perlin 1999:135). Judging by the speed with which companies moved into the household market initially, and then used similar marketing and distribution methods, it is reasonable to assume that information and knowledge flowed quite freely between them.

This was a serious issue for Solar Shamba. Burris was known to make enemies of those he considered to be less technically conscientious than he was or, at least, those who did not practise to minimum technical standards (Hankins 2007; Kithokoi 2008). With the rapid growth of the PV market and increasing competition, many were finding ways to cut costs and this was most easily done by omitting the charge regulator, using thinner wires, installing batteries of inadequate capacity or quality, including incandescent lamps instead of fluorescents, and choosing modules of insufficient power output for the needs of the system. Burris tended to openly criticise those technicians, or others, who made use of any of these practices. As a result, (Hankins 2007):

> [Although] Harry had put a business model in place … he wasn't the type of person to attract business from an investor – that is, investors would not find him an attractive proposition. He was so adamantly independent. The business community in Nairobi steered clear of him and wouldn't invest in him and the technicians, except for the ones he worked closely with, didn't bring him business. They just started doing business on their own, the companies set up their own marketing channels, and left Harry out. Gradually, Harry was becoming isolated.

Burris left Kenya towards the end of 1987 or in early 1988 (Hankins 1990:70; 2007). Although Solar Shamba stopped doing business, Daniel Kithokoi, who had been working closely with Burris, started his own company – Solar Energy Installations – and continued to work in Meru, the area he had been covering while with Burris (Hankins 1990:70; 2007; Kithokoi 2008).

5.3.2 PV as consumer product

Two interesting developments occurred in the market during 1989. First, amorphous modules became available in Kenya (van der Plas and Hankins 1998:298). Second, it seems that Chintu Engineering was given the license to assemble these amorphous (Chronar) modules and began supplying them separately, and as part of complete solar lighting kits, from May 1989 (Hankins 1990:63). Chintu supplied the modules and kits through its own three branches, a dealer network and, most notably, through Argos Furnishers, a very large company with over 30 branches in Kenya (Hankins 1990:64, 69). Argos offered the kits on a cash or hire-purchase basis – "in the same way that they provide credit terms for bicycles, televisions and sewing machines" (Hankins 1993:39) – the first time PV was available on any credit terms to the consumer (Hankins 1990:64). It was already widely recognised, of course, that the initial cost of a PV system was high and that this could be a problem for the adoption of the technology, even if the life-time cost could be competitive with other technologies. However, those supplying the household market in Kenya did not have the cash flow necessary to introduce hire-purchase, or other credit schemes, into their selling strategies. Hankins (1993:39) notes:

> A shortage of credit for potential system buyers is the greatest impediment to expansion of PV sales. Many potential customers have steady incomes but are unable to amass the initial capital required to purchase systems. Local dealers cannot profitably offer credit because their own cash flow is limited and because of the problems associated with collection of debt.

It appears that Chintu was doing well on the basis of supplying these kits and selling them through Argos, as well as others. According to Hankins (1990:64), the company sold 1200 modules in less than one year after introducing the kits (500 of them to Argos) and had assembled another 1000 kits by May 1990. However, the hire-purchase offering ended when Argos closed many of its rural outlets “due to economic reasons” (Hankins and Bess 1994:14). Those reasons are not given but the period following the introduction of the kits was a difficult one in the Kenyan economy; a period that Acker and Kammen (1996:90) describe as a “two-year tailspin”, particularly after the suspension of quick disbursing aid by donors starting in early 1992. Figure 5.2 shows the rapid increase in the CPI (consumer price index) and fall in the value of the Kenyan Shilling against the US Dollar, the CPI only really coming under control in 1995 even if the Shilling has never recovered.

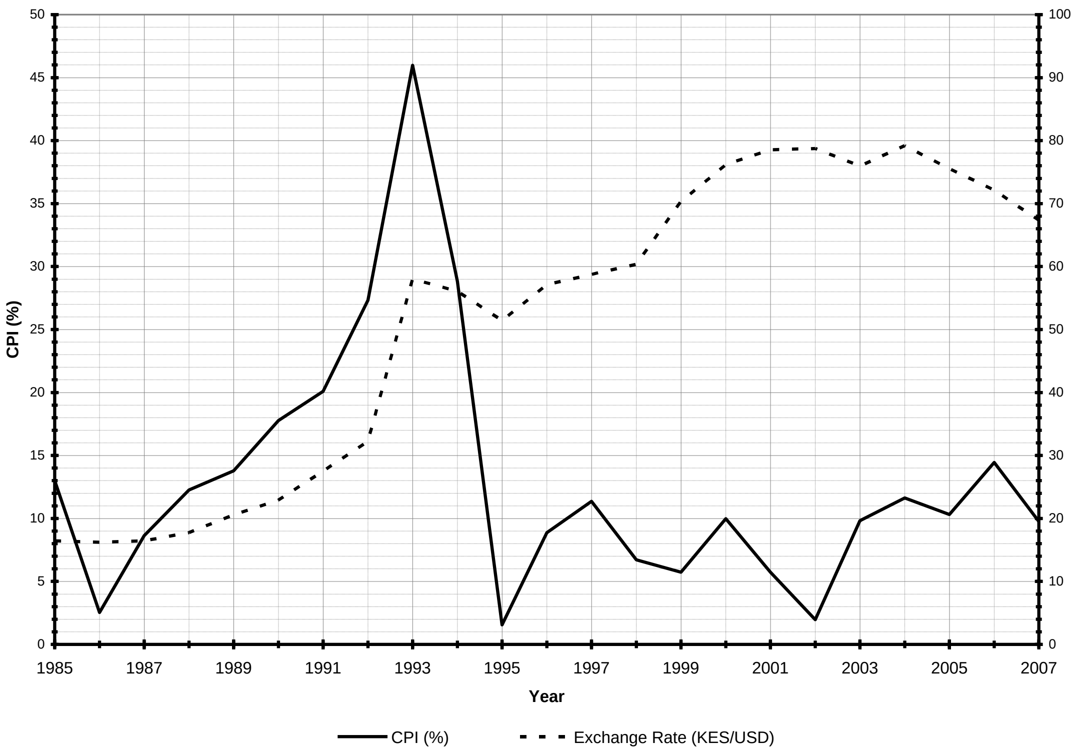

Figure 5.2: Consumer Price Index and Exchange Rate of Kenyan Shilling to the US Dollar, 1985 to 2007
Source: African Development Indicators (2009)

5.3.3 Analysis of developing marketing models

Total Solar and the dealer network

It is not entirely clear why Total moved into the PV market. According to Rioba (2008) they were only doing this for ‘greenwashing’, perhaps a response to the growing environmental awareness worldwide. Nevertheless, they had most of the solar water heater market (70%) and may have thought there was a sizeable donor market in PV worth pursuing. In time, however, it was the household market that became more important to their business. Whatever the explanation for Total Solar’s involvement, the evidence does suggest that they were the first to develop the dealer-network approach. And, over the next few years, other companies embraced this approach as the competitive pressures in the market intensified.

For Rioba this was an important period of learning. He had gone to Total Solar purposefully to learn and he certainly gained technical training as well the experience of setting up the dealer network. While doing this he also gained useful experience of the market and how to sell to it, although this may have been more indirectly through dealers than directly through interactions with customers. He also saw the effectiveness of demonstration systems for generating business. Indeed, the dealers would have seen the importance of this strategy themselves.

It is difficult to identify whether Rioba’s learning was of a first or second-order quality. He may have experienced both kinds. We can be reasonably certain, however, that he had some form of expectation that guided his decision to join Total Solar. The source of this is likely to be a combination of the experiences he gained working in the MERD and studying renewable energies for his masters degree. Out of these experiences we could suppose that he formed a somewhat vague socio-technical expectation that incorporated renewable energies and business in Kenya. Given that his first degree was in chemical engineering, we can think of his forming of a personal socio-technical expectation as the result of second-order learning: he had changed his assumptions and was attempting to achieve a new goal. The learning that followed was concerned more with the detail of this expectation: technical details of PV, how to establish a dealer network, how to stimulate local markets, and so on. His activities, then, began to articulate some of the detail and so helped him to form a socio-technical vision, in the

Berkhout (2006) sense, but on a personal level. Some of this was collectivised by interactions with dealers and the installation of demonstration systems.

For other companies, the existence of a dealer network and demonstration systems were observable and, therefore, possible to imitate. Moreover, Total Solar appeared to be doing quite well in terms of business and this would have served to demonstrate a market demand in more of the rural areas. We can see here a possible method by which Total Solar's business and distribution model could be copied, and a possible reason for companies wanting to copy it. However, apart from the fact that other companies adopted a dealer-network approach, we do not have the evidence to conclude that they actually copied from Total Solar.

The dealer network that Total Solar developed was important for generating more business, of course, but it was also important for raising awareness of PV among more Kenyans. Likewise, the networks developed later by other companies had this effect. Further, the technical training that Total Solar conducted within its own network helped to establish at least some PV-specific skills around the country. While it is likely that this training was not as comprehensive as that given by Burris and Hankins (Rioba talks of three or four days to cover both solar thermal and electric systems), it was an attempt to institutionalise professional practice of a degree.

Chintu, Argos and hire purchase

For market growth, the introduction of amorphous modules was important because they were significantly cheaper than the crystalline variety, even though the poor quality of the modules caused many problems (see section 5.7.1). From the customer's perspective, however, a lower price was not the only benefit. The modules were rated at 12 to 14 Wp, a good match for a PV system that could power a portable TV. The modules began selling quickly, although it is difficult to know to what extent this was because of their size-price characteristic and to what extent it was because of the hire-purchase offering through Argos. But, clearly, the development was a significant articulation of market demand and, in terms of units sold rather than watts-peak, soon became the most popular PV module in the Kenyan market (van der Plas and Hankins 1998).

We would expect that, once the hire purchase option was demonstrated to be effective for generating business, the other companies would have introduced their own hire purchase schemes. But this was a difficult process to manage. Argos already had plenty of experience with other products and so was able to include the kits relatively easily. For the other companies in the PV market, this would have been a risky venture that would have required setting up hire purchase schemes, or some other form of credit facility, from nothing: no existing procedures and no prior experience.

So, while we can suppose that learning would have occurred about consumer-credit among other players in the market, and perhaps created a desire to imitate such a facility, we can see that this was not enough to stimulate its widespread diffusion. Significantly more information, knowledge and experience were necessary, not all of which were observable, before other actors could adopt this approach. Moreover, the Kenyan economy went into a difficult period soon after this, causing Argos to close many of its outlets. It is reasonable to assume that, even if others were considering the introduction of hire purchase at this point, the difficulties were too complex and the economy too weak to risk such a move.

5.4 Broadcasting the news

This section is about dissemination of the Kenya PV phenomenon outside of the market actors in Kenya. The first attempt at this is in Hankins (1987). It was his first book and covers renewable energy in Kenya in general. While there is a chapter on solar energy, there is only about half a page on the PV market specifically. In this, he could point to just a few hundred systems installed and so it would be difficult to persuade anyone that there actually was a phenomenon. Still, there are some other aspects of this first attempt to disseminate that might be important in terms of niche development. First, Hankins had to do the research. That meant travelling around Kenya to various projects and so he would have been able to network far more extensively than he had done before this. The book was paid for by USAID and, latterly, the Canadians. So, Hankins was building a reputation among some of the donors that would be helpful to him later.

5.4.1 Dissemination and recruitment

Hankins left Kenya towards the end of 1987 and returned to the US. He struggled to find a way back to Kenya but was certainly trying. Eventually, he went to do his MSc at Reading (the same as Rioba's) in 1989. For this, he went to Kenya to do his fieldwork in 1990. He then discovered that the market had flourished since he had left. He did a survey of a number of PV systems and wrote this up for his dissertation. The "message" in this was "picked up by the World Bank". This time, although it may still have been a modest phenomenon, Hankins had very detailed descriptions of the uses of PV systems in rural areas of Kenya, some of which were for 'productive uses'. He had also captured some of the local practices, good and bad.

Hankins did other research including a trip around eastern and southern Africa during which he met many involved in PV. He also did research for another book, this time funded by SELF. Late 1991 or early 1992 he teamed up with Kenya Environmental Non-Governmental Organizations (KENGO) in order to organise a regional workshop on PV, an idea that Hankins and Burris had conceived. He had put a proposal into the African Development Foundation (ADF) in the US (having been encouraged by a contact there who was an ex-Peace Corps). Hankins invited many of the contacts he had made during his trip around eastern and southern Africa to attend the workshop. In addition to these, ADF wanted some representatives from organisations it was going to fund to attend as well. They were Oswald Kasaizi of Karagwe Development Association (KARADEA) and Martin Saning'o of Moipo Integrated People's Organization, both from Tanzania.

The workshop was held in Nairobi during March 1992 and was attended by people from across East and Southern Africa, including some from the ministries of energy in Kenya and Tanzania. (Actually, it was a broad selection: private sector, NGOs, government, universities, donors, individuals.) The format of the workshop included formal presentations, training content, and practical work to install a PV system in a rural area (Meru, where Burris had been working). For Hankins, it was highly successful. He had two or three immediate possibilities for projects come out of the workshop. Two of these were in Tanzania, one each with Kasaizi and Saning'o. In order to get the funding for these, he had to work through a legally registered organisation and so started Energy

Alternatives Africa (EAA) with Daniel Kithokoi. Hankins also claims that this was the time when SolarNet was started, although it was an unofficial organisation at this point and had no funding. The two Tanzanian projects were to set up a solar training centre at KARADEA, located in the north-west of the country and very difficult to access, and to test solar lanterns in the Maasai areas of northern Tanzania through Saning'o's organisation.

The KARADEA project proposal was developed during a visit by Burris and his wife late in 1992. Hankins did not attend at this time. However, this was also when the GEF was about to start its PV project in Zimbabwe and Burris was appointed chief technical advisor to it. He was, therefore, unable to pursue the KARADEA project and Peter de Groot of the Commonwealth Science Council brought Hankins in instead. Kasaizi and Hankins then put the proposal together for what became the KARADEA Solar Training Facility (KSTF), which the CSC funded. It involved a building that included a classroom, PV equipment and other facilities for training PV technicians. (This is discussed in more detail in chapter 6, section 6.3.1).

Hankins also wrote his textbook and got this published in 1991. He then updated it and published in 1995. These were, and still are, important for institutionalising best-practice for PV design and installation. He did the 1993 book and he also teamed up with Bess for the ESMAP paper of 1994. These two, in particular, helped to articulate the Kenya PV phenomenon more widely than Kenya.

5.4.2 Analysis of dissemination and recruitment

This was a highly active period for building networks and disseminating experiences. Hankins' primary immediate objective was "to get published and to write a book" (Hankins 2007). He used his experience of working on PV installations as a basis to further this objective: he formed something of a personal expectation or vision, where the goal was to get published and the means included writing about PV. His first opportunity to realise this came with the 1987 book on renewable energy in Kenya for which he had to conduct extensive research around the country. He included a short section in the book on the current state of the PV sector but this was a straightforward list of the numbers and types of systems installed in Kenya.

His research enabled him to network much more than he would have done prior to the book. The book covered most renewable energies and so could not treat any one of them too deeply. Even so, Hankins was able to learn a great deal about the extent of the PV sector in Kenya and to establish contacts in addition to those he already had through his work with Burris. Hankins had already formed a personal socio-technical expectation about PV in Kenya and now he was able to start refining this into a vision through the learning he was doing in his research. This would most likely have been of a first-order quality: the kinds of systems in operation and their locations; who was working with the technology; the extent and nature of successes and failures; and so on. Some of these details were included in the book but it was, for the most part, a catalogue of the state of renewable energy in Kenya. As such, it was a useful means for wider dissemination.

More significant, however, was Hankins' MSc dissertation. This was focused exclusively on PV in Kenya, and articulated considerable detail of both the supply and demand sides of the market. He documented how the supply chains were working and how people in rural areas were actually using the technology, sometimes for productive purposes but mainly to improve the immediate quality of their lives. He learned about some of the problems in the market, some of which were technical issues and some to do with user-practices. Here was an opportunity for him to persuade donors that there was a phenomenon worth encouraging – one that aligned with their institutional interests – but one that needed support and, therefore, it was an opportunity for Hankins to find work in Kenya.

In his 1987 book, Hankins had already started expressing a socio-technical expectation of PV in Kenya. Now he was able to strengthen his 'bid' by referring to "thousands of systems installed through a private market" rather than the "hundreds" that were in place during the period of the research for his first book. This private sector phenomenon allowed him to connect with the increasingly dominant free-market paradigm that framed much of development thinking. He could point to the "success" of the Kenyan PV market in diffusing an environmentally benign technology, which also supported development goals, while highlighting ways that it could be improved, in terms of scale and quality, through donor intervention. Whether these arguments – this socio-technical vision – formed the basis of his early proposals is not possible to say but he certainly framed his later descriptions in this way.

Hankins was certainly successful at attracting funding, and much of this enabled him to develop networks, both inside and outside Kenya, through which he could disseminate and develop a PV socio-technical vision. The money he received from the Canadians helped him to make contacts across east and southern Africa, many of whom participated in the Regional Workshop in Nairobi in 1992. That event was, of course, both a networking and learning opportunity for the participants but it was also during this that Hankins was able to mobilise resources for projects in the region. In order to make use of these opportunities, he started EAA together with Daniel Kithokoi and their work helped the company to become the most important PV actor in the region.

One of those early projects was with KARADEA to help establish KSTF, the first specialised PV training centre in East Africa. The relationship between EAA and KSTF persisted for about ten years during which 175 PV technicians, mostly from East Africa, were trained at the facility (KSTF 2009). Over that period, at least five donors supported the work: CSC, Sida, APSO, Hivos, and Ashden Trust. So, network-building has been extensive through the KSTF project. And the project maintained a space in which the basic PV training course could be developed and refined. Indeed, the KSTF course was something of a model for other courses conducted later in the region. For example, the courses developed for TaTEDO in Tanzania (see chapter 6, section 6.3.5) were based to a large extent on the KSTF experience and the 1995 edition of Hankins' textbook. So the KSTF collaboration was important for institutionalising PV practices in East Africa, developing networks, and collectivising PV socio-technical visions.

We can see that this period was important for network-building and dissemination. While these have continued, it appears that it was here that the dominant form of the Kenyan socio-technical vision of private sector led PV development was refined and collectivised. Hankins was influential throughout this process and has expressed this vision in his papers, books, proposals and reports, as well as in training courses and other networking events. It has been a persuasive vision because of the fact of the rapid growth of the Kenyan PV market. Hankins, and others who followed, have accentuated the private sector aspect of PV market growth in Kenya and downplayed any donor influence. The somewhat paradoxical effect of this has been to convince a wide range of donors to fund interventions and other activities. These resources facilitated the early network-building, dissemination and training that have been important for the learning, collectivising of visions and embedding of practices that helped to stimulate and sustain the growth of the PV market.

5.5 Controlled experiments

This section investigates a number of research and development activities that occurred in Kenya, beginning in 1994. These activities can be categorised into two broad themes: product design and development; and market surveys. A third category – PV cell research and manufacture – has been the focus of activity in the Physics Department of the University of Nairobi, but has been largely disconnected from the local commercial sector while being networked with international academic research. There is little to say other than the interest is in 'wet cell' research, something that is not yet commercial, and does not seem to have had any appreciable impact on the Kenyan PV niche. The other two categories of activity have been conducted by commercial actors and have helped to articulate the Kenyan PV market in their own ways, in sometimes fine detail. The research and development activities investigated here are not all those that have occurred in Kenya as that would be practically impossible to achieve. Instead, they constitute a sample (see Table 5.1) that serves to highlight the co-evolutionary dynamics of the SNM conceptual elements and niche growth.

5.5.1 Articulating the market

As we have seen, soon after EAA were formed they began to implement projects in the region. Two of the earliest projects were conducted in Tanzania but, in 1995, they began a solar lantern project in Kenya and there followed a long period during which they managed many other PV-related projects in the country. This section describes four technology projects they implemented, but also includes some description of the activities of Leo Blyth, who came to Kenya from the UK searching for a way to disseminate micro-solar kits.

Table 5.1: The activities investigated.

Activity or Project	**Years**
Product Design and Development	
Solar Lantern test marketing	1995 to 1996
Micro Solar	1996 to present
Jua Tosha battery	1997 to 1998
Battery Pack	1997 to 1999
BOS components	1999 to 2001
Market Surveys	
Survey of 410 SHSs	1996 to 1997
STEP (Solar Technician Evaluation Project)	2000 to 2001
Survey of East African PV markets	2002 to 2003

It is clear that, as early as 1990, Hankins was interested in the market possibilities of solar lanterns, although he considered them to be too expensive, too constrained in functionality, and difficult to repair locally (Hankins 1990:80). Even so, he saw their potential to bring electrical services to a poorer segment of the population, and to do so as engineered systems rather than the *ad hoc* 'systems' that were becoming commonplace in the market[33] (Hankins 1996:8-9). Through EAA, and funded by SELF, he had already worked with Saning'o in northern Tanzania to supply a few batches of lanterns (OSEP 1998; Byrne 1999:13; Hankins 2007; SELF 2009). The Kenyan project, however, differed from the Saning'o experiment in that the lanterns were placed in a sample of rural shops rather than being supplied through an NGO. This was a more market-friendly approach than the first lantern project and marked the beginning of a method that EAA used in many subsequent projects.

From those already available on the market, six models of lantern were selected for test-marketing and a seventh, prototyped by EAA themselves, was added (Hankins 1996:11). These were supplied to six dealers: five in rural areas around Mount Kenya and one in Nairobi (Hankins 1996:14). EAA tested a sample of the lanterns in-house and later questioned 65% of those who bought lanterns, as well as asking the dealers for

[33] These 'systems' consisted of low quality PV components bought piecemeal and connected together without any design considerations.

their opinions. There was a number of findings related to technical issues, functionality, consumer practices and preferences, the impact of taxes on price, supplier needs, and some suggestions for ways to strengthen the marketing of lanterns.

The technical issues concerned the quality of the designs and how these might be improved. Functionality included recommendations for powering a radio as well as a light. Consumers were found to be conservative in their purchasing, especially the lower income groups: the best selling lantern had a shape similar to a pressure lamp; middle-income groups tended to buy the lanterns first, lower-income groups were less likely to take risks; and consumers did not like the monochrome light of LEDs. Taxes were seen to add about 30% to the price of lanterns because they were categorised as lamps rather than PV systems (PV modules were taxed at either 10% or 0%). The needs of suppliers included access to a small range of standardised spares, which was also seen as a way to overcome some of the risk-averse behaviour of customers who would not buy a lantern unless spares were available. And three marketing methods were suggested. One, lanterns could be supplied in two stages: the customer would buy the lantern first, and then pay for it to be charged until the cost of the module had been collected, upon which the customer would then receive the module. Two, a new product could be introduced that consisted of a battery and charge regulator combined into a single unit. The battery could then be recharged using a battery charging service, and the customer could get access to electricity while saving to expand their 'system' to include a PV module and better lamps later. Third, hire purchase or other financing schemes could be used to help customers buy solar lanterns (Hankins 1996:31-36).

EAA managed to secure funding for projects to pursue two product ideas they, or Hankins, had suggested in the solar lantern report. One of these was for a small locally manufactured 'solar' battery, or "Jua Tosha" as it became called; the other was for a "BatPack", the battery and charge regulator unit mentioned above (Hankins 1996:36). Both projects got underway in 1997. For the BatPack, Ashden Trust funded EAA and ApproTEC to develop a prototype and this was ready in 1998 (EAA 2001:5). The Jua Tosha project, supported by ESMAP, began in June 1997 and the first of a total of 800 batteries manufactured by AIBM were being shipped to up-country retailers by November (Ochieng *et al*. 1999:9). Production of the BatPack – this second phase of the project being funded by ESMAP – did not get underway until April 1999, and test-marketing started in November (EAA 2001:13).

The Jua Tosha project was largely successful: the battery was well received by the market, and dealers, who had not considered a 20 Ah battery[34] necessary, now wanted to see continued production (Ochieng *et al*. 1999:27) and by the time of the report (August 1999) more than 200 units per month were being sold (Ochieng *et al*. 1999:2). Also, one of the other battery manufacturers – ABM, who had first introduced a 50 Ah solar battery in 1985 – started production of a 40 Ah solar battery[35] (Ochieng *et al*. 1999:27; EAA 2001:4).

The BatPack project was considered unsuccessful in terms of its original objectives (EAA 2001): the product was unattractive to its target market, few units were sold, and there were unresolved technical problems with the charge control unit. Eventually, EAA decided to import a similar product – the Sundaya Battery Pack (from Indonesia) – and they test-marketed this instead, beginning January 2000 (EAA 2001:8, 14). Apart from the technical problems with the Rodson controller, it was discovered that an investment of around USD 15,000 for a mould would be required if the BatPack casing were to be made from plastic, a large risk for a small Kenyan company considering that thousands of units would have to be sold to recoup the investment (EAA 2001:8n6).

While the BatPack report states the project was unsuccessful, other aspects were highlighted in an effort to suggest that the project achieved some positive outcomes. One of these outcomes was an identified demand for this type of product, albeit among a higher income group than anticipated and for a higher specification unit than the one tested, unless the price could be reduced sufficiently. Evidence to support this claim included the observation that other suppliers, who were not involved in the project, began sourcing similar but higher-specification products from outside Kenya (EAA 2001). Another success claimed in the report was that Rodson, who had designed the charge controller, were said to have introduced two new products to the market as a result of their involvement in the project: a charge controller and a battery monitor (EAA 2001). While it was probably fair to say the BatPack project inspired these

[34] In practice, the battery was measured to have a 30 Ah capacity (Ochieng *et al*. 1999:22).
[35] EAA (2001:4n5) state that the battery probably had a lower capacity than the manufacturer claimed.

product ideas, the work to design and develop the products appears to have been through a project funded by MESP, and begun about September 1999 (Osawa 2000). Osawa (2008) remembers that there was a period during the early 2000s – up to about 2006 – when local manufacture of BOS components was very successful: indeed, EAA (2001:2) report that Rodson were selling “several hundred” battery monitors and charge controllers per month. However, local manufacturing of BOS components has almost disappeared as a result of Chinese-made products coming into the Kenyan market (Osawa 2008).

For all these projects, EAA used a similar methodology. They persuaded up-country dealers to stock the prototype in their shops, waited for a period and then questioned the dealers and customers about their experiences with the product. They also tested the product themselves, either in-house or with the help of an independent actor, to document the technical specification.

However, in the BOS components project they introduced a new aspect by including focus groups with consumers and, separately, with dealers *before* the prototypes[36] were manufactured. The results of these focus groups informed the choices of products to manufacture and refinements to the designs of those chosen. The BOS project had initially proposed six product concepts and the two that appeared to meet the most immediate market demand – battery monitor and charge controller – were the ones developed by Rodson (Osawa 2000).

A number of technical and functional issues were raised during the consultation and test phases of the product development (Osawa 2000). One, Rodson were requested to reduce the value considered a full battery charge so that the full indicator would be illuminated for longer, providing a ‘better’ customer experience. Two, Rodson were requested to lower the value set for the low voltage disconnect so as to provide electrical services for longer. Three, Rodson were asked to introduce a reset button that would allow a few minutes of electricity supply once the low voltage disconnect had activated, giving the user light while they set up a kerosene lantern, for example. And,

[36] The information provided to the focus groups was in the form of pictures of the product concepts, and proposed functional and technical specifications (Osawa 2000).

fourth, the charge controller was modified after it was discovered that it could not cope properly with inductive loads such as fluorescent lamps.

Another important feature of the way in which EAA worked throughout these projects was the extent of their networking. Between the four projects discussed here, they interacted with at least 39 different dealers and suppliers in 16 cities, towns and villages around Kenya, and at least five of the dealers were involved in more than one project (Hankins 1996:14; Ochieng *et al*. 1999:v; Osawa 2000; EAA 2001:31). These numbers do not include the manufacturers, donors and other organisations with whom EAA worked: AIBM, Chloride Exide and Rodson; ESMAP, Ashden Trust and MESP; and ApproTEC, ITDG, SolarNet and the University of Nairobi Physics Department.

Finally, it is interesting to say something about the activities of Leo Blyth. After his first visit to Kenya in 1996, Blyth spent a number of years moving back and forth between Kenya and the UK, trying to disseminate DIY Solar[37] kits when in Kenya, and finish a development studies degree in the UK. His dissemination efforts included training people to make the solar kits, conducting dozens of such courses in Kenya and other countries in the region, and with various groups including Trans World Radio, SolarNet and the Peace Corps (Blyth 2008). One such course was conducted in the Nairobi slum Kibera in June 2004 (Keane 2005:7) and it may have been here that Fred Migai, who has so far been the only Kenyan to try to commercialise the idea (Blyth 2008), learned to assemble the kits.

However, Blyth himself tried to commercialise a product idea around 2002 with funding from the Shell Foundation, developing the idea out of his experiences in the region with these ‘micro-solar’ kits and other products he had seen. He had also shown a few of the Chinese micro-solar products that appeared on the local market to Hankins who liked the ideas but was concerned about the quality (Blyth 2008). For the Shell Foundation project, he worked with EAA and used the BOS project methodology as a template. Following focus groups with consumers, a product to charge a mobile phone and power a radio was chosen and the project was to get 1000 units manufactured in China.

[37] DIY Solar was an idea developed by Graham Knight in Ashford, Kent in the UK. He made use of ‘discarded’ amorphous PV modules from Intersolar, which he cut into smaller pieces and fixed wires directly to the back in order to power devices such as radios (Blyth 2008).

However, the manufacturer “ate the money” and the project collapsed (Blyth 2008). Migai now assembles a simple kit that can charge a mobile phone and power a radio, although it does not have a charge controller or battery, and sells the kits up-country himself and through a network of agents (Migai 2008). Before he learned how to assemble the micro-solar kits, Migai had been a marketing agent for Swiss Guard, selling a healthcare product in Kenya through a pyramid marketing scheme (Blyth 2008). It appears that the methods he uses to sell the micro-solar kits are similar to those he practised while working for Swiss Guard, and he claims to be selling around 100 solar kits per month (Migai 2007).

While Blyth continued to try to commercialise micro-solar products in Kenya, he now considers local manufacture to be the wrong direction: it takes large amounts of investment and needs large volumes to be viable, otherwise the transaction costs are too high (Blyth 2008). Indeed, Osawa (2008) has come to the same conclusion regarding manufacture in Kenya. It is interesting to note that no actors, other than Blyth and Migai, were keen to discuss micro-solar technologies or the Shell Foundation project. Moreover, there appears to be considerable scepticism among many of the established PV actors over micro-solar, notwithstanding the general interest that Hankins showed.

5.5.2 Analysis of technical projects

It is clear that the implementation of these various projects generated deep interactions between actors from different sectors and throughout the PV supply chain within Kenya. Further, the projects provided opportunities to learn a great deal about both the supply and demand sides of the PV market: about user practices and preferences; supply-side practices and assumptions; technical details of product concepts; and formal institutional constraints such as VAT and other taxes. We can also see that there was important system-building work being done by some actors, EAA being perhaps the most significant of these. Hankins, in particular, appears to have developed a proposal model that succeeded in aligning the interests of the development regime and the needs of actors within the Kenyan PV niche, while linking to others such as battery manufacturers and electronics specialists. By deploying a socio-technical vision in which PV diffusion could be achieved through the private sector, he was able to attract resources for experimentation that the private sector would have found too risky to provide, but from which it benefited significantly.

The learning generated by these experiments resulted in better articulation of the rural market in two senses: a clearer description of its characteristics, and a strengthening of interconnections between actors in the supply chain. In turn, this better articulation, in both its senses, helped to enhance and collectivise expectations of market demand. Equipped with a richer understanding, actors changed their behaviours and introduced new products to the market guided by finer-detailed socio-technical visions. This is not to say that the projects were straightforward, consensual and positive in all their aspects: there were technical problems, negative outcomes and, at least where micro-solar products are concerned, the *suggestion* of dissensus.

Where technical problems were concerned, their solution was generally the result of first-order learning: for example, the modification to the Rodson charge controller so that it could cope with inductive loads (BOS components project); and the sourcing of a product similar to the battery pack when the Rodson control circuit could not be made to work (BatPack project). It was also through first-order learning that expectations were developed into visions: more precise detail of various aspects such as consumer demand, consumer practices and preferences, willingness to pay, product functionality and quality, local manufacturing capacity, and the impact on price of taxes. This filling in of details was important for niche actors because it lowered the risk of investments for them: they had better information about the market and their role in it, enabling them to articulate business models.

In regard to negative outcomes, it is interesting to observe that these were a source of second-order learning. For example, the lack of demand for the battery packs challenged assumptions that shifted actors' expectations. The shift, in this case, was from targeting a poorer segment of the population to a wealthier one. At the same time, the challenge to assumptions generated a new understanding of the preferences of the poorer segment: that functionality and price are far more important than convenience. And Blyth appeared to adjust his expectations about the means to achieve greater diffusion of micro-solar products based on what we might characterise as the negative outcomes of his experiences working with NGOs: the disappointing adoption rates for the solar kits he demonstrated.

However, unlike the private actors in the other projects we have discussed, it took a long time for Blyth to realise this shift in expectations. The explanation for his persistence could lie partly in his personal expectation that PV was “not just another product” and therefore could ‘win’ on its own terms, and partly in the examples of two actors who did not see PV in this way. Instead, at least one of them – Migai – marketed micro-solar in a similar way to other small products and achieved some success. Here, Blyth was presented with an alternative vision, at least in terms of the means by which micro-solar technology diffusion could be realised, and it is one he appears to have assimilated. This suggests that second-order learning can occur as a result of positive outcomes as well as negative but, in this case, it occurred through observation of the positive outcome for others: a kind of vicarious second-order learning. Indeed, we can see that something similar occurred with the Jua Tosha battery (the other battery manufacturer in Kenya, who was not involved with the project, introduced its own small solar battery soon after the project finished) and, in some ways, with the Batpack project (another supplier, again not involved with the project, sourced a similar product, even if this did not result in any market penetration).

Second-order learning *opportunities* may also exist as a result of the dissensus over micro-solar products. It is not entirely clear from the evidence but we could reasonably argue that the paucity of experiments with micro-solar products, and the consequent lack of assumption-testing, is one source of this dissensus. There is some testing going on but it is not being documented or studied systematically: Chinese companies are trying various products in the market, and Migai is selling units through a network of individuals. The only project that would have provided some documented testing of assumptions was that funded by the Shell Foundation but, as with many projects that are considered failures, documentation is difficult to find and few actors want to discuss it. Nevertheless, the characteristics of micro-solar products appear to be aligned closely with practices and preferences among consumers in Kenya, and so we might expect the products to be easily embedded in the market. Further, the movement in the market has been toward smaller systems, and much of the motivation for the projects described above has been to enhance the technical quality of such systems. Moreover, there is growing interest in the ‘Bottom of the Pyramid’ approach to development, and micro-solar appears well-aligned with this expectation.

Given these conditions, it is difficult to understand why the micro-solar ‘market’ has not attracted much interest from the established PV actors in the region or from donors. On the contrary, the current situation is that many of the established PV actors hold negative expectations about micro-solar; only a few actors hold positive expectations and are using these to guide their activities. These micro-solar ‘promoters’ seem to be working almost entirely in the private sector with meagre resources and independently of each other. However, having said this, the World Bank’s *Lighting Africa* project may be an indication that the situation is beginning to change, at least as far as lighting products are concerned (World Bank 2007). Indeed, Blyth is now a consultant to the *Lighting Africa* project (Blyth 2009).

Finally, it is important to recognise that these projects involved many of the same actors; that there was a consistency or stability in the networks of actors. Certainly new actors joined and not all the actors participated in all the projects. Nevertheless, this relative stability facilitated the building of trust (this has been important for eliciting information for market surveys), and the accumulation of knowledge generated in the projects. Moreover, EAA has been a central actor in these activities, as well as many other projects not considered here. This has been important for at least two reasons: one, it has enabled EAA to be a cosmopolitan actor in the local PV niche, in the sense used by Deuten (2003); and two, it has enabled the building of local capacity at this cosmopolitan level.

We can see then that these projects were important for niche building in Kenya. They were initiated primarily to test technologies but generated significant effects beyond the first-order learning that SNM would expect of such technology-testing experiments, essential though this first-order learning is to creating the detail of visions. The projects also generated second-order learning for actors within and outside the project-networks and this resulted in shifted expectations and changes to behaviour. We cannot be certain that the learning and other effects would not have happened without the projects but we can see that the private sector would have considered such experimentation as risky. Donor-funding gave some protection against these risks and the experiments provided a means to test assumptions as well as technologies.

But the experiments also brought local actors together in a way that enabled rich interactions over many years, thereby facilitating the exchange of information, and the collectivising of expectations and visions. We also saw that EAA were central to much of the activity discussed here (indeed, they have been central to much activity not examined in this section) and this helped them to become an increasingly skilful cosmopolitan actor. They identified project opportunities, attracted funding, managed projects and networks of actors, accumulated knowledge, and built local capacity at the cosmopolitan level.

By contrast, the micro-solar experience has been one in which the networks are fragmented, expectations are not widely collectivised – indeed, they appear to be contested – and learning has been, for the most part, individual rather than collective. With learning poorly articulated, it has been difficult to form expectations that *could* be collectivised. If expectations were collectivised then it may increase the chances of attracting other actors and resources to experiments that could generate further learning.

5.5.3 Market surveys

There has been a number of surveys of the Kenyan PV market and, as we would expect, they have served to articulate and codify many aspects of it. We have already considered two of these in relation to the dissemination of the PV phenomenon in Kenya. Both of these were conducted by Hankins (1987; 1990): the 1987 survey was more of a cataloguing project, while the 1990 survey investigated some of the detail of the demand and supply sides of the market. Since then, there have been perhaps eight surveys that have focused on the PV niche in Kenya. Numerous other studies have been conducted but they have either incorporated PV into a larger survey or they have not been surveys. Of the eight that are focused on the PV niche, one is unavailable[38] (Musinga *et al*. 1997). Consequently, the discussion here is based on the other seven

[38] In fact, this survey of 1000 households may not be focused on the PV niche, it may have focused on non-PV households.

surveys: Hankins and Bess (1994), Acker and Kammen (1996), Hankins *et al*. (1997), Jacobson (2002a; 2002b; 2004) and ESD (2003).

The Acker and Kammen survey was conducted in July and August of 1994 and included, among other aspects, interviews with 40 owners of PV systems sized between 10 Wp and 100 Wp (Acker and Kammen 1996:93). It asked similar questions to Hankins' 1990 research and found similar benefits and problems. In this sense, it supported Hankins' work and further elaborated his initial articulation of the market: who was buying systems, the kinds of systems, how they were being used, how consumers learned of PV, consumer expenditures, performance of systems, typical benefits and problems, and (an addition to the information gained by Hankins) the distance to the grid.

Some of the more surprising findings of the survey included the discovery that PV systems were being bought by people who could not be considered affluent, and some appeared to have struggled to acquire their systems (Acker and Kammen 1996:95):

> Many of the households whose annual incomes are less than the survey average of US$2800 are spending over 75% of their income for their systems, with some homes spending almost 200%.

Indeed, a visual inspection of one of the graphs in the document suggests that up to a quarter of the systems investigated in the survey were bought by people who had an annual income of less than USD 1000, and a few of these systems cost more than USD 1000 (Acker and Kammen 1996:96, Figure 23). The understanding up to this point was that reasonably well paid consumers, or cash crop farmers and other business people, were buying systems (Hankins 1990:3; Hankins and Bess 1994). Another interesting finding was that a quarter of the systems were in homes within 1 km of the grid – in partial support of an estimate of 40% given in Hankins and Bess (1994:5, cited in Acker and Kammen 1996:96) – even though the "break-even distance beyond which PV would be cheaper" was estimated to be 8.8 km, and that one of the systems was in a home actually connected to the grid (Acker and Kammen 1996:96).

One of the questions that was not asked was whether, and how much, savings were sustained as a result of using PV systems. The next survey of household systems investigated this question, along with many of the same dimensions addressed by the Acker and Kammen study. The survey, funded by ESMAP, was conducted through EAA from December 1996 to March 1997 and covered 410 household systems in 12 districts across Kenya (Hankins *et al*. 1997:2), forming the basis of an *Energy Policy* paper written by Robert van der Plas of the World Bank and Mark Hankins (van der Plas and Hankins 1998). The savings the survey found were most significant for smaller systems and, overall, the majority of savings were on kerosene and dry cells, equally shared (Hankins *et al*. 1997:37-38). The significance of the savings enjoyed by those with smaller systems was heightened because there appeared to be a trend in the market toward smaller systems, already indicated to some extent in the Acker and Kammen study (Acker and Kammen 1996:97, Figure 26), facilitated by the availability of 12 Wp amorphous modules. The average savings were about USD 10 per month and, for those with systems smaller than 15 Wp, USD 8.55 (mostly on dry cells but also on kerosene and battery charging) (Hankins *et al*. 1997:36-38).

Other than these findings, the survey was generally in line with the findings of the previous studies but, of course, the number of systems investigated made it an important articulation of the market. And this enabled Hankins *et al*. to present detailed recommendations assigned to all types of actors with an interest in the market: government, donors, industry, financial institutions, NGOs, and research organisations (Hankins *et al*. 1997:47-53). There were also recommendations made from the Acker and Kammen survey, and the Hankins *et al*. study overlapped with these in a number of ways: the need for supportive policy, both national and international; the need for capacity building; that finance schemes should be introduced; standards and codes of practice should be developed to overcome the quality problems; there was a need for better and impartial information; and, there should be smaller engineered systems, such as solar lanterns, and more modular provision of system components in the market (Acker and Kammen 1996:105-108; Hankins *et al*. 1997:47-53). It is interesting to note that the Hankins *et al*. recommendations made a point of insisting that subsidies were not to be used to promote PV (Hankins *et al*. 1997:48):

> “Project” (public sector) funds should be channeled in ways which will grow the market, without subsidizing systems or Government institutions.

This was in line with the report's general assessment of the PV market in Kenya being a private sector phenomenon. In the introduction to the report, it states that there had been an "absence of Government, finance or donor support – or any project intervention effort" in the Kenyan PV market, acknowledging only that "[s]everal independent volunteer initiatives were instrumental in catalyzing the existing market, but these were neither expensive nor large scale" (Hankins *et al*. 1997:9, n2). This is interesting because there have been recent changes to this position, at least on the part of ESD who now talk of "smart subsidies" (ESD 2003).

Jacobson, with the help of others and working through EAA/ESD, conducted a number of surveys between 2000 and 2004 (sample size in brackets): Solar Technicians (366); Solar Vendors (312); Solar Households (76); and Energy Allocation (15 households) (Jacobson 2004:302-309). For the solar technician (STEP – Solar Technician Evaluation Project) and vendor surveys, Jacobson employed two local technicians to conduct the majority of the field work: Maina Mumbi and Henry Watitwa (Jacobson 2002a:7). For the household study, Jacobson employed the same two technicians to conduct many of the interviews (Jacobson 2004:304). The energy allocation survey involved using data logging equipment to measure appliance use over a period of four to six months for each system, and was supplemented with ethnographic observations (Jacobson 2004:306-307).

The technician and vendor surveys were important because they characterised the supply side of the market more thoroughly than had been achieved up to that time. The main findings from the technician survey were that most technicians (90%) operating in the PV market were not solar specialists, and only 5% of solar technicians had regular employment in PV services (Jacobson 2002a:9, 11). Similarly, the vendor survey discovered that only 5% of shops stocking PV equipment were specialists, and 41% were hire purchase shops (Jacobson 2002b:31).

The most important conclusion that Jacobson drew from these findings was that PV training courses needed to be re-designed to be shorter, delivered in up-country locations, and targeted to the needs of non-specialists who were, nonetheless, working in the PV market (Jacobson 2002a:8). This was a departure from the form in which EAA had been conducting their training courses for many years, developed from the three-schools project in 1985 and the work at KSTF since 1993. Whether it was a result of the study or not, the training courses supported through PVMTI since 2006 seem to be arranged according to Jacobson's recommendations to some extent, particularly the delivery of courses up-country and the targeting of non-specialists (Nyaga 2007; PVMTI 2009). And an interesting impact of having employed two local technicians to conduct the majority of the interviews was that their interactions with so many other technicians stimulated discussions of forming their own association, KESTA (Kenya Solar Technician Association) (Watitwa 2008). Although KESTA was officially registered in 2005 (SolarNet 2005:28), it had not secured any funding, or managed to collect membership fees, by the time of this research (Watitwa 2008).

The two other surveys conducted by Jacobson during 2003 and 2004 provided insights into the dynamics of electricity-use within the household. Although the sample was very small in the energy allocation survey – just 15 systems – the detailed information of appliance use, combined with observational material and interviews, provided evidence of a more complex reality of electricity consumption patterns in the home than was previously available. It was assumed that electric light benefited women and children, reducing their exposure to kerosene fumes in the kitchen and improving conditions for studying at home. Or, at least, this was the rhetoric within the development regime in regard to connections between electricity and development. Jacobson's survey discovered that this was not necessarily the case, particularly in households with small systems. He found that TV dominated electricity consumption in homes that had a small system (less than 25 Wp), using 54% of the energy available, and that the kitchen often had a low priority when deciding where to install lights; while with larger systems the majority of energy consumption was for lights (61%), TV accounting for one third of consumption (Jacobson 2004:204-232; Jacobson 2007:153-155). It is unclear whether these findings have had any impact on the rhetoric around PV and development; it may be too soon to be able to notice any effect.

The most recent survey of the PV market was conducted for the World Bank through ESD in 2003 and covered seven countries of eastern Africa. One of the stated aims of the study was to be able to describe the development of PV markets in the region. The results showed quite different kinds of markets across the countries studied, with Kenya clearly the largest and most developed, described as "mature" (ESD 2003). It updated some of the fundamental information about the market such as installed capacity, but also provided statistics on numbers of companies and technicians operating, described increasing complexity in the supply chains and marketing strategies, and gave figures for awareness of PV among the population. Above all, however, it gave a detailed and highly prescriptive set of recommendations on how to develop PV markets in the region including, for the first time, some support for the use of subsidies in PV promotion, argued on the basis that PV markets had been stimulated to grow rapidly in some of the industrialised countries through the use of subsidies (ESD 2003). And, the recommendations appear to have been influential on the interventions that happened in Tanzania soon after the report was finished, as we shall discuss in chapter 6, particularly in section 6.4.3.

5.5.4 Analysis of market surveys

As we might expect, these various market surveys provided a large amount of detailed information about both the demand and supply sides of the Kenyan PV market. In SNM terms, we can characterise this as predominantly first-order learning: that is, generating finer detail about what is already generally understood. However, it is important to recognise that the surveys occasionally generated information that challenged the assumptions of different actors: that is, we can identify some second-order learning.

While the Hankins (1990) and Acker and Kammen (1996) surveys provided some useful information that helped to detail both supply and demand side practices, they were based on very small samples. The ESMAP-funded survey of 410 households was much more significant. It generated a great deal of first-order learning that enabled a much finer articulation of the market (in the descriptive sense), particularly the demand side. On the basis of this articulation, it was possible to express a persuasive socio-technical vision of PV in Kenya: the objective of rural-household demand for basic electrical services was being provided through the means of PV systems sold in a private market. Further, the observation that the market was moving to smaller systems suggested an extension to this vision or, in some ways, a new expectation: access to electrical services could be deepened to include poorer groups among the population by introducing more ‘micro-electricity’ products into the market and providing finance packages “to lower the initial cost” (Hankins *et al*. 1997:52).

Indeed, EAA had already shown an interest in micro-electricity products, having test-marketed solar lanterns. Notwithstanding this experiment with the lanterns, the precise details of these micro-electricity products were not yet defined, neither were the details of the finance packages recommended in the survey report (Hankins *et al*. 1997:3, 52). Both these aspects of the expectation were the focus of projects that got underway almost immediately: so quickly[39], in fact, that EAA had probably formed the expectation prior to the survey, making use of the results to help them collectivise it. The Jua Tosha and BatPack projects, as we saw in section 5.5.1, went some way to articulating the details of micro-electricity products, while the process of articulating finance packages was the focus of a project discussed below in section 5.6.1. This expectation persisted over time and was adopted – perhaps adapted, in conjunction with experiences from elsewhere – by many actors in the development regime, and in PV niches in Kenya and other developing countries. And we have seen the development regime fund projects that have served to articulate it – envision it, so to speak – while trying to realise its promise, particularly with regard to consumer credit as micro-finance has emerged as a favoured development tool.

However, Jacobson's research provided a refinement to this expectation, perhaps even a challenge to some aspects of it. His findings concerning intra-household energy allocations refined part of what had become a highly collectivised vision: the benefits in the household of PV light compared to kerosene, especially for women and children. It is perhaps too early to assess whether this will cause any second-order quality change in expectations or visions among actors in the development regime or PV niches, but the dominance of this vision seems to be intact for now. Jacobson's other challenge was that extending credit would not extend access to PV-generated electrical services. As mentioned above, there is currently a great deal of interest in the use of micro-finance for extending services into the lives of poorer groups in developing countries and this continues to be tested together with PV systems. However, there are signs that this is changing. Hankins has begun to talk of "smart subsidies", arguing that the PV markets have grown quickly in industrialised countries because of generous subsidies. And the

[39] The Jua Tosha and BatPack projects got underway in 1997, before the household survey report was finalised (Ochieng *et al*. 1999:9; EAA 2001:5). The finance project was already in a preparatory phase in December 1996, as the household survey was beginning (Hankins and van der Plas 2000:25 Box 5-1).

GEF has introduced a form of smart subsidy into TEDAP, the most recent World Bank electrification project in Tanzania. I am not suggesting that this is because of Jacobson's research, merely that it may have been part of this move away from the rhetoric of 'pure' market forces.

The STEP survey also, to some extent, challenged an aspect of the dominant socio-technical vision of PV in Kenya. Although little work had been done to study solar technicians in the market, there was an assumption that they were earning a living by installing and maintaining systems. Jacobson challenged this by showing that the majority of technicians could only secure an occasional job in the PV sector and so it was just one of many sources of income. The survey also achieved three other things. One, it showed the extent of 'coverage' of technicians in the country and codified these findings. Two, by employing two solar technicians to administer the survey it helped to connect the technicians together in a way that had not been attempted previously. An interesting outcome of this was that the technicians created their own association, KESTA, as a way to promote their interests. In doing so, they created a channel for collectivising an expectation that may express their perspective within the Kenyan PV sector. So, the survey stimulated a network effect. Three, the STEP survey appears to have contributed to developing a different, but standardised, training package for technicians.

Perhaps the most interesting part of the ESD (2003) report, from our perspective, is that it makes a list of detailed recommendations that express an accumulation of knowledge gained by EAA/ESD over the preceding decade. Moreover, the recommendations can be read altogether as a clear and finely articulated socio-technical vision of how PV-diffusion through eastern African markets can be successfully achieved. Indeed, as we shall see in chapter 6, these recommendations appear to have influenced the more recent interventions in Tanzania.

The recommendations also indicate a slight departure from the more full-blooded free-market approach to PV-diffusion of the earlier reports. A notable addition here is the advocacy of smart subsidies, based on the argument that subsidies have been important for the growth of PV markets in industrialised countries. This certainly marks a change of assumptions and we could interpret this change as a *vicarious* second-order learning effect, as PV markets in industrialised countries provided the source of learning. But it may also reflect the shift in thinking within the development regime – the Post-Washington Consensus – and the 'rediscovery' of the role of government. Whether this was the case or not, a significant part of the explanation for the interest in subsidies may lie in the desire to raise quality in the PV market. In this sense, it recognises a market failure: the Kenyan PV market, applauded for being 'undistorted' by subsidies, has seen a downward spiralling of quality as competitive pressures have caused private actors to cut costs wherever possible; smart subsidies are seen as a way to add value to better quality systems so that private actors are encouraged to eschew the race to the bottom.

Apart from this shift towards the use of subsidies, however, the document can be seen as a statement of the knowledge of the PV sector in Kenya that had been cultivated by a number of actors over the course of at least a decade – longer in the case of Hankins. It expresses a very clear vision of how to diffuse PV systems and, because it comes from ESD – a well-recognised cosmopolitan actor in the region, it carries authority and can be interpreted as the *dominant* socio-technical vision within the PV niche.

5.6 Scaling up

This section is about attempts to experiment with, and provide, finance for PV systems in order to extend access to electrical services and stimulate PV-market growth. There were two important projects in this regard, funded or supported by donors: an ESMAP-Ashden Trust project that got underway in 1996; and PVMTI that started officially in 1998. Both projects were intended to be models for replication in Kenya and elsewhere, hence the notion of 'scaling up'.

5.6.1 Who gets the credit?

Finance was already believed to be a significant problem that was frustrating the further, and deeper, diffusion of PV in Kenya (Hankins 1990; Hankins and Bess 1994; Hankins 1996:35-36), particularly as there was evidence that some kind of credit facility, such as hire purchase, would increase the sales of PV systems (Hankins 1990). But it was not until 1996 that any serious attempt was made to experiment with financing schemes. ESMAP and the Ashden Trust provided funds under the management of EAA, together with K-REP (Kenya Rural Enterprise Programme) and the CBK (Co-operative Bank of Kenya), to test a number of approaches (Hankins and van der Plas 2000:17).

Three approaches were attempted, as outlined in Hankins and van der Plas (2000:19-20). Two slightly different approaches were tried by K-REP, who normally did not provide non-business finance. The first involved self-selection of groups[40] around Mount Kenya; groups already familiar to EAA and who were knowledgeable about PV systems. The second approach involved selection of groups by K-REP themselves. They identified five groups in Bungoma District in Western Kenya: three of them being registered self-help groups of teachers “with regular savings contributions and bank accounts, but without … rigid savings rules”; and two groups formed especially to access the SHS loans available through the project and so “were unstructured, unregistered, and lacking in savings activities” (Hankins and van der Plas 2000:19). The third approach was that attempted by CBK. They selected two well-established tea and dairy SACCOs, already familiar to CBK; groups “with memberships numbering in the thousands that have established management structures, constitutions, meeting schedules and bank accounts” (Hankins and van der Plas 2000:20).

Initially, there was scepticism and reluctance to offer finance for SHSs, particularly among the senior management of K-REP (Hankins and van der Plas 2000:38). PV was essentially an unknown for them and so viewed as risky. However, they were persuaded to join the project believing that the donor support would mitigate this risk. Once the experiment had been agreed, the basic structure of the initial phase of the project was to meet a local community, usually at a SACCO general meeting, to explain what SHSs were, and what they could and could not power. In each case, there was a limited number of systems available for the first round of financing and, because there was so much demand for the financed systems, all these were usually ordered immediately at the end of the meeting. The experiences in the project were mixed: for K-REP, the experience was a difficult one; for CBK, it was largely successful.

[40] The ‘groups’ referred to are collections of individuals who have come together to form some kind of cooperative in order to get access to credit that they may not otherwise be able to secure through the mainstream banking system *as individuals*.

The self-selected Mount Kenya groups through which K-REP tried to offer SHS loans were particularly problematic. The familiarity of the groups with EAA was initially thought to be beneficial to the project but turned out to be a problem as the groups expected more favourable conditions such as subsidised finance and system costs. Following increased demands from the groups over the lending terms, K-REP recalled its loans in May 1997 (Hankins and van der Plas 2000:25).

For the K-REP selected groups in Western Kenya, loans were disbursed to 35 customers by December 1997 and system installations began from February 1998 but then "irregularities began to occur" (Hankins and van der Plas 2000:26). The problems centred around technical issues with some of the systems but led to several months of disputes between the installers, K-REP and the customers. The final assessment of this part of the project, at the end of 1999, was that (Hankins and van der Plas 2000:26-27):

> … 50 percent of the outstanding loan value had been repaid. Some 17 percent of the households had paid off early; 17 percent were on time with repayments; 17 percent were somewhat behind; 46 percent are in default; and 3 percent had their equipment repossessed. …
>
> Problems encountered were the following: people refused to pay when their system malfunctioned; technicians failed to honor their commitment to provide maintenance services over the two years of the loan repayment; and technicians failed to respond to customer requests for assistance. Finally, loan repayment seemed to be taken less seriously over time.

CBK worked with two SACCOs in succession. First, they worked with the tea SACCO quite successfully and then, following disagreements over loan conditions for the second round of finance, began working with the dairy SACCO (EAA 2001:17). There were 14 installations through the first SACCO and one round of systems installed through the second. But the arrangement with the second cooperative, the dairy SACCO, ran into problems because of a national dairy crisis[41] (Hankins and van der Plas 2000:20). This was compounded by the timing of the second round of installations, due to begin in March 1999, a period when many farmers have other financial obligations[42] (EAA 2001:17).

[41] There was a "collapse in the Kenyan dairy market and Kenya Creameries Company" (Hankins and van der Plas 2000:20).
[42] Hankins and van der Plas (2000:20) note that "[r]ural people prefer to buy SHSs during the last quarter of the year. In other quarters, they have heavy financial loads (school fees, agricultural investments, etc.)".

However, about 100 PV systems were financed and installed through the project and there were positive indications that the two financial institutions would continue to provide SHS finance products (Hankins 2004:25; Hankins and van der Plas 2000). Further, the project experience informed the implementation of PVMTI (Osawa 2008) and one of the outputs was an implementation manual[43] meant to assist dissemination and replication. Despite these apparently positive developments, financing through the established finance organisations and SACCOs continues to be problematic, while hire purchase schemes appear to be working successfully (Hankins 2004:22): indeed, as Jacobson (2002b:31) discovered, hire purchase shops are the most common suppliers of PV equipment to consumers. Hankins (2004:22) estimates that there is likely to be more than USD 1 million of business in the hire purchase of PV in Kenya per year, despite the high cost to the consumer.

5.6.2 Market transformation: the GEF-IFC supported PVMTI

The PVMTI project was intended to make a total of USD 5 million finance available on both the demand and supply sides of the Kenyan PV market, and to be implemented over ten years, beginning July 1st 1998 (Gunning 2003:81). Finance for customers would enable them to overcome the high initial cost of PV systems and therefore release pent-up demand. Finance for companies would allow them to purchase in bulk and so reduce their costs, hence lowering prices to consumers. The project was to be implemented in three countries simultaneously: Kenya, Morocco and India. Kenya was "viewed as a true free market for PV products" (IFC 1998:12). With a total investment across the three countries of USD 25 million, and addressing what was seen as the finance bottle-neck to market transformation, the project was expected to have a discernible impact on sales in the world market: specifically, the impact was expected to be about a 5% increase in world PV sales within five years (IFC 1998:14).

The project got underway officially in Kenya in 1998 with the request for proposals issued in September (Gunning 2003:85). As the terms of lending were leverage of 1:1 and a minimum PVMTI investment of USD 0.5 million, companies in Kenya were forced to come together as consortiums because no single company could risk such an amount of money (Ngigi 2008; Bresson 2001:5). One of the first consortiums to submit

[43] The Hankins and van der Plas (2000) document.

a proposal involved CBK together with Chloride and EAA. This received “first-track” status, meaning that it was acceptable in principle and ready for implementation (Ngigi 2008). However, the IFC had issues with investing in CBK because of their non-performing assets, and decided the proposal was not bankable. Soon after this, according to Ngigi (2008), disparaging articles began appearing in the local media and EAA became one of PVMTI’s biggest critics. Certainly, by 2001, there was evident disquiet and impatience expressed by some in the SolarNet[44] newsletter (Muchiri 2001:4; de Bakker 2001:4-5; Bresson 2001:5-6).

Other proposals were received (Hankins and van der Plas 2000; Ngigi 2008), and a long process of negotiations ensued: negotiations between the consortiums and the IFC; and, when these failed to produce deals, local financial institutions were persuaded to engage with the project, these deals collapsing after more protracted negotiations (Ngigi 2008). Eventually, it appeared that most of the available finance would finally be disbursed. Three deals were agreed: one with Barclays Bank, Kenya; one with Equity Building Society; and one with Muramati Tea Growers SACCO (who had been involved with the earlier EAA-managed finance project) (Hankins and van der Plas 2000:29).

However, the Barclays deal fell apart soon after becoming operational. KUSCCO, an umbrella group of SACCOs, was to be the conduit between Barclays and SACCOs, thereby bundling many small deals together for Barclays so that they could lower their own transaction costs. These did not materialise quickly and Barclays were unhappy with the arrangement; KUSCCO were unhappy with bringing customers to Barclays, a competitor; and the SACCOs were unhappy because the delays lowered their reputation among customers. After a long period of problems, the relationships went stale (Ngigi 2008).

The Equity Building Society deal also collapsed, again after a protracted period of delays and negotiations (Ngigi 2008). Equity were to finance PV entrepreneurs with PVMTI guaranteeing the risk, and a deal was put together for USD 2 million. But the IFC had problems with the security terms, which appeared to be overcome when Equity offered Treasury Bonds. A year later, the agreement was signed but then the Central

[44] SolarNet is a network for renewable energy promotion in the region and was publishing a widely read newsletter a few times per year.

Bank of Kenya said that the bonds would have to be held by a legal company representing the IFC. The IFC refused these terms, jeopardising the deal. Other ideas were floated but nothing was finalised. By this time, Equity, which was growing quickly, wanted to convert to a commercial bank and the deal with the IFC might have adversely affected this prospect. So, nothing more was done and the deal, as Ngigi (2008) describes it, "fizzled out".

The Muramati experience was, as with all the other projects, long and painful, if partially successful. Over the course of three years, and involving considerable effort to persuade the SACCO to be part of the project, a deal of USD 600,000 was agreed and the IFC provided the loan directly to the SACCO (Ngigi 2008). However, there were technical problems with the batteries for the systems, and the SACCO was unhappy with the service provided by the technical partner. Following a "very bitter" meeting with the Muramati stakeholders, the project was wound up and the money returned, although about 150 to 170 systems had been installed (Ngigi 2008; IFC 2007:42).

The disquiet and impatience mentioned above turned to resentment among some actors in the PV niche in Kenya. They began discussing, among themselves, ways in which PVMTI might be changed in order to provide some tangible benefit to the market (van der Vleuten 2008), and approached PVMTI in 2003 requesting help with capacity-building (Magambo 2006:1). In 2004, PVMTI went through a restructuring (IFC 2007:42). As a result of meetings with PV actors in Kenya and the frustrations felt within the PVMTI hierarchy itself (Ngigi 2008), together with the evidence from Jacobson concerning training and quality needs (Jacobson 2002a, b), and the availability of some technical assistance[45] grant money, PVMTI began a capacity-building project in Kenya in 2006 (IFC 2007:42; PVMTI 2009). The grant of USD 350,000, together with "in-kind contributions and co-financing" of USD 115,000, was used to support KEREA, the development of a PV curriculum, PV training courses, the production of three manuals (user, seller, and installer manuals), and a quality assurance programme (IFC 2007:42; PVMTI 2009; Nyaga 2007; Magambo 2006). PVMTI has been extended

[45] Ten percent of PVMTI money was already available for grants for exactly the kinds of activities the stakeholders wanted funded (IFC 1998). It is unclear why it took so long for the money to be made available in-country. But, additional grant money was made available after the grant component was increased to 20 percent (Ngigi 2008; IFC 2007).

to 2011, and there appears to be a change among PV actors towards a favourable view of the project more recently (Ngigi 2008).

5.6.3 Analysis of finance projects

The two financing projects served to articulate important aspects of the Kenyan PV market, in both the senses of ‘articulation’ that we are using. Links were created between the PV niche, and the local finance and international development regimes, with important potential implications for niche growth, and institutional alignment and embedding. Market growth, as a direct result of the two projects, was only marginal: perhaps 300 systems were added to the installed capacity of PV in Kenya through these projects. But niche development was somewhat more significant. New actors, particularly from the local finance regime, became engaged in the PV networks; more consumers were introduced to the SHS concept; there were richer interactions between existing niche actors; and institutional embedding was deepened. The processes of establishing links involved work to collectivise expectations among actors in the PV niche and local finance regime, and to envision these expectations among all concerned – those in the PV niche, the local finance regime *and* the international development regime. These connections, of course, extended the networks but the nature of these connections – collaboration based on (initially) shared expectations – facilitated deep interactions that generated learning of both first and second order qualities. First-order learning enabled the other sense of articulation: the detailed description of particular elements of the market that helped to envision expectations. However, there were also second-order learning experiences and these resulted in shifted expectations that guided actors to changed behaviours.

The first project was driven by the expectation that finance would unlock pent-up demand, increasing PV sales and deepening access to electrical services. For K-REP, CBK, and a number of SACCOs and similar groups, there was second-order learning involved in their recruitment to this expectation. That is, for them, it was a new expectation. It was a difficult experience for many but the persistence of CBK, K-REP and at least one of the SACCOs indicates that they did indeed adopt the expectation sufficiently to allocate resources for its realisation. Most of the learning that subsequently took place was of a first-order quality: that financing does increase demand; the detail of how to structure loans; what interest rates the market will support; who are good customers, who are not; how to organise the financial and technical partnerships; and so on. This learning was then collectivised, beyond those in the project, by the publication of an implementation manual that was meant to act as a guide for others who wanted to introduce SHS loans in rural areas of developing countries. Indeed, it became a template for some of the consortiums that submitted proposals to the subsequent PVMTI project. So the manual had an institutionalising impact.

The initial expectation that finance would unlock demand remained unchallenged as PVMTI got underway, and may, in fact, have been heightened by the experience of the first project combined with the intentions of PVMTI. But the misalignment of institutions – between the IFC lending rules and practices within the Kenyan finance regime – that led to the rejection of the CBK-Chloride-EAA proposal generated a prominent critic within the PV niche. This was certainly a problem in itself, not least because EAA were "an opinion leader" (Ngigi 2008). Nevertheless, proposals continued to flow and many actors held onto their expectation that PVMTI would eventually be able to deliver, evidenced by the SolarNet articles as late as 2001. But the further experiences of niche actors interacting with the misaligned – and rigid – institutions of the development and local finance regimes, and the consequent delays and rejections, created more and more personal negative expectations about PVMTI. These negative expectations were readily collectivised through the enhanced networks that PVMTI, somewhat ironically, had helped to develop – by compelling actors to come together in consortiums to submit proposals, the relationships and communications between them were deeper and more complex than those of straightforward competitors.

This enhanced collectivisation of actors in the PV niche, in turn, enabled them to lobby the PVMTI hierarchy to adjust the detail of the intervention. It was clear to the niche actors that the particular finance vision expressed in the design of PVMTI was inadequate; a second-order quality of learning, considering that the same actors had adopted the vision at the beginning of the project. Frustrations among some actors within PVMTI itself created an opportunity for second-order learning to occur there also, with the result that the project shifted its expectation to one of market-support activities. The first-order learning, that the IFC lending rules were inappropriate for the kinds of conditions in the PV niche in Kenya, could not readily be incorporated because it would have required going through the entire project design process again. Rather, these lessons, according to Ngigi (2008), have informed the design of other financing arrangements such as the World Bank-GVEP Energy Access Fund.

So, we can interpret the PVMTI experience as one that contributed to niche development but not market growth. The interactions of groups of niche actors were deepened by the need to collaborate on proposals, and broadened to include actors from the potentially complementary finance regime. Positive expectations turned to negative and motivated action to address long-standing problems in the market concerning quality; something that may not have happened if PVMTI had worked as hoped. The standard PV curriculum, training courses, and three manuals that resulted from these actions are all clearly institutionalising instruments. And an industry association – KEREA – received financial support that may help to maintain, develop and expand the application of these instruments over time.

However, the processes of learning in the two projects were often contentious, protracted and painful. Part of the explanation for the difficulty in realising second-order learning in particular may lie in the persistence of a free-market ideology; a ‘deep’ assumption, let us say, operating as a landscape factor that constrained ‘shallower’ assumptions such as those expressed in the expectations that guided these project interventions. In other words, the free-market diffusion of PV systems was a deeply held and widely shared fundamental assumption guiding all other actions. Efforts were then focused on making this work, shaped in their detail by the contentions and negotiations that ensued. Indeed, the fundamental assumption seems to have remained intact, bolstered perhaps by the reported success of retailers’ hire purchase schemes, and attempts to deepen access to PV-generated electrical services continue to experiment with both large-scale and micro financing.

5.7 Policy regime interactions

This section is about the processes of writing PV standards and formulating energy policy. This is interesting for the development of policy, of course, but also for the way in which it reveals the politics that are generated at the regime level. Perhaps this is an inevitable effect of interaction with regime actors: because the stakes are higher here, politics come into play much more.

5.7.1 PV standards

For many years, the lack of standards for PV in Kenya was a recurrent issue, raised time and again during workshops, seminars, and in the writings about the market (Hankins 1990; Hankins 1993; Hankins and Bess 1994; Acker and Kammen 1996). The donor-funded installations, at least those such as the WHO-EPI systems, had their own standards but there were no Kenyan standards that could be applied in the private market. We have already discussed the attitudes to technical standards of some of the pioneers in the Kenyan PV market, and some of the practices on both the supply and demand sides that emerged from the highly competitive environment of the late 1980s. Despite the many calls for technical standards that resulted from the recognition of these practices, it was not until the mid 1990s that there appears to have been any attempt to persuade KEBS (Kenya Bureau of Standards) to do something about the issue. This initial attempt to get KEBS to formulate technical standards failed (Gisore 2002:47), possibly because it was attempted only by a single actor (Loh 2007). However, in 1998, KEBS "revisited" the development of PV standards following "increased demands from various quarters" (Gisore 2002:47). It is not clear what this means but there was mounting evidence that there were serious problems with some of the products and practices in the PV market (Hankins 1990; Hankins and Bess 1994; Acker and Kammen 1996; Hankins *et al*. 1997), and there were international moves to develop PV standards (PVGAP 1996; PVGAP 1998).

In any case, KEBS decided to initiate a standards process for all the renewable energy technologies, starting with PV. This got underway officially on April 28th 1999, consisting of a committee of about 12 invited stakeholders from the renewable energies sector in Kenya (Gisore 2002:47-48; Loh 2007). The process of writing the standards consisted, in essence, of monthly meetings for which the committee members reviewed draft standards such as PVGAP, wrote outlines, and discussed what should be included, excluded, and what needed work (Loh 2007).

While this sounds like an essentially technocratic process, there is some evidence that it was not straightforward. Two extracts from a presentation given by Gisore, the KEBS representative on the committee, hint at the sometimes contentious deliberations that unfolded and why they were so (Gisore 2002:49):

> As an activity that touches on the social and economic aspects of stakeholders, agreements on the standards and codes of practice have been based on consensus. This has not been easy. Many times members have had to vigorously demonstrate the negative or positive effects which certain requirements in the standards or codes of practice will have on the subject matter. Many times consensus has not been reached in a single sitting, and this accounts for the fact that it has taken almost three years to have most of the standards get approval as Kenya standards.

And, Gisore (2002:50):

> For those components manufactured locally, due considerations were given to ensure that the standards did not serve to push [their manufacturers] against the wall.

Nevertheless, by the time Gisore gave this presentation in August 2002, much of the standards work for PV was complete, even if not everything had been formally agreed (Gisore 2002).

Sometime during 2001 to 2002, the committee members began to discuss the idea of forming an association. The argument, according to Loh (2007), was that it would be:

> … better that the association has its rules and governs itself before the Government comes in and puts its hand into saying all these things and getting licenses. Better a well-regulated industry …

Both KEBS and MOE were “very keen” on the idea and KEREA (Kenya Renewable Energy Association) was “very quickly registered, in August 2002” (Loh 2007). One of the first efforts of KEREA was to conduct a technical evaluation of the amorphous silicon modules on the market in Kenya.

The “amorphous question” (Ochieng 1999:19) was something of a refrain in Kenyan PV circles, and there had been a major study of the performance of the modules available on the local market, conducted in 1999 by EAA, RAEL at the University of California and STEP at Princeton University (Duke *et al*. 2000). That study found that one manufacturer's amorphous modules performed very poorly, and the company responded by improving its manufacturing process (Jacobson and Kammen 2005:1). Despite this success, new low-quality brands of amorphous modules appeared on the market and so Arne Jacobson offered to conduct a fresh set of tests for KEREA (Loh 2007; Jacobson and Kammen 2005:1).

There was difficulty to agree the terms of this evaluation but, eventually, KEREA members agreed to the methodology, and a sample of modules were shipped to the US in 2004 where Jacobson and colleagues performed the tests over the period from September 2004 to March 2005 (Jacobson and Kammen 2005; Loh 2007). Two brands of modules were found to be severely over-rated and so, in line with the terms of the evaluation, the importers of these agreed to remove them from the market (Jacobson and Kammen 2005; Loh 2007). By February 2005, before the results of the module evaluation were ready, KEREA had a code of conduct in place (KEREA 2005). The efficacy of the code of conduct was, therefore, tested almost immediately. According Loh (2007), it was the peer pressure that KEREA members could bring to bear, based on the agreed code of conduct, that achieved the removal of the modules from the market and "many people were quite chuffed about it that we [KEREA] managed to do something like that … KEREA became something more credible".

5.7.2 Analysis of the PV standards process

The process of formulating PV standards in Kenya was a site for considerable first-order learning, as actors were focused on the details of what those standards should be. Clearly, this entailed substantial technical discussions that encompassed draft standards such as those being developed through PVGAP, the experiences and expertise of the local niche actors, and the requirements of the Kenyan regulatory regime.

But we can identify some second-order learning that was also important in the process. This second-order learning occurred much earlier for some niche actors when they realised that there were quality problems[46] in the market. Based on this realisation, they formed a new expectation, perhaps even vision, in which the solution to these quality

[46] For Burris, of course, this was an issue from the outset. And Hankins was an early recruit to Burris' vision.

problems was to regulate the market using standards. They made repeated attempts to collectivise their understanding by expressing a vision of a PV market that was successful and of high quality, with the enforcement of standards as the means to achieve this objective. In fact, they presented two visions. The other, which was to some extent being realised in the market, was a negative vision in which consumers were losing, and business would fail, because of bad practices. Eventually, KEBS was recruited to this vision and initiated an official standards-making process, although it is not clear why this second-order learning did not occur sooner for them.

The process also contributed to the enhancement of networks within the niche, as was the case with other projects we have already discussed. For some of the actors involved, their only interactions with others in the niche had been an occasional business deal; now they were meeting regularly to discuss issues other than business (Loh 2007). And it was out of this close interaction that they formed an industry association (KEREA). We could see this as a second-order learning experience in that they formed a new expectation, related to the standards issue, in which one of the objectives was a high-quality PV sector[47] that could be achieved by self-regulation of the factors not covered by the technical standards. This expectation was then envisioned to some extent by the formulation of a code of conduct, and the initial embedding of this when they managed to persuade the 'guilty' KEREA members to remove low-quality modules from the market.

One other aspect of the standards process, for which we have only *suggestive* evidence, is the contention generated by this kind of action. We can interpret standards as socio-technical visions: they are highly detailed prescriptions for certain aspects of action and so intended to formally institutionalise particular behaviour. In this sense, the niche actors on the committee were negotiating a vision of serious importance to them: each could be affected in different ways by the outcome of the process; that some could be winners and others losers, depending on the constraints imposed by the institution. Gisore (2002:49-50) hints that this was indeed how some of the deliberations of the committee unfolded, and is more explicit when he states that the process included consideration of the consequences for local actors. Unfortunately, we cannot examine

[47] Of course, KEREA covers other renewable energy technologies as well as PV, and the code of conduct is for all its members.

these negotiations because we do not have the evidence and, therefore, cannot assess to what extent they shaped niche development. But, we can recognise that important niche-shaping action resulted from the process, and that the process was inherently political.

5.7.3 Energy policy proposals and politics

Around the middle of 2001, the process of preparing a new energy policy began within the Ministry of Energy, and discussions were initiated involving various Government departments and representatives from parastatals (Theuri 2008). Except in their individual capacity, no other energy-sector stakeholders were invited to participate at this point. However, there was at least some interaction between the ministry and others in the renewable energies private sector. Daniel Theuri, the Acting Director of the Department for Renewable Energy, worked with both Mark Hankins and Bernard Osawa of EAA within the IGAD Regional Household Energy Project, writing a handful of papers related to energy in Kenya (Theuri and Hankins 2000; Theuri and Osawa 2001; Osawa and Theuri 2001), possibly the first substantive and formal collaboration between the ministry and actors in the non-commercial renewable energy sector[48] in Kenya.

Soon after this official MOE process got underway, towards the end of 2001, EAA began talking with DFID about the possibility of funding an energy policy discussion process. Early in 2002, DFID agreed to fund what became known as the Policy Dialogue and the first session took place on May 21st in Nairobi (Mutimba 2007; Bess 2002:1). Another five meetings took place that year: one each in June, August, September, October and December (Policy Dialogue website; Mutimba 2002a, b, c: page 1 in each case).

The MOE policy was “already taking shape” by December 2001 (Theuri 2008) but sometime in 2002 the UNDP country office was asked to support the process (UNEP 2006). Theuri (2008) states that the draft policy was ready by April 2004 but Mutimba (2007) claims that the Policy Dialogue had managed to get hold of a copy of the draft during 2003, following which they drafted an alternative policy and submitted this to the MOE by the end of the year. Whatever the precise details of the drafting timeline,

[48] There were interactions of some kind before this but they were mainly at seminars and workshops such as the 1992 Regional Training and Awareness Workshop (Kimani 1992).

during which there seems to have been some tension and politics between the Policy Dialogue and the MOE processes (Mutimba 2007), a Sessional Paper was indeed passed towards the end of 2004. However, it took another two years before this became the Energy Act.

During those two years, there were more “cat and mouse games” between the MOE, Parliamentarians and the Policy Dialogue (represented by ESD[49]), as well as interventions by the ‘traditional’ energy actors such as the utility and those in the petroleum sector (Mutimba 2007; Otieno 2007). In terms of the MOE-Policy Dialogue interactions, one account has it that the MOE “took the [Policy Dialogue] document and oppressed it a bit” (Mutimba 2007), but used much of it as the official energy policy; while another account claims that the influence of the Policy Dialogue was only really on the charcoal policy (Theuri 2008). It is not possible to verify either of these accounts but we do have detailed information from Otieno (2007) on how the MOE attempted to have its version of the policy endorsed by the parliamentary committee on energy. For reasons that are unclear, Otieno and Mutimba were present as observers[50] at this meeting. According to Otieno, he and Mutimba realised that the policy the MOE was presenting had “everything to do with renewable energy extracted”, and informed the committee of this. There then ensued the “cat and mouse games” between the ministry, the committee and ESD. In essence, the parliamentarians insisted that the MOE reinstate the renewables passages, having been briefed by ESD and GTZ about the details. Eventually, partly because of the MOE’s “fear” of the parliamentarians[51] (Mutimba 2007), a compromise was reached whereby the renewables components were, at least, strengthened again (Otieno 2007). As a result of this experience, Otieno “realised that the parliamentarians have a critical role in formulating policy and have an upper say when it comes to the ministry”. In response to requests from the parliamentarians, GTZ supported the forming of a network – the Parliamentary Network on Renewable Energy and Climate Change – in which ESDA and others conducted seminars for the parliamentarians on renewable energies (Otieno 2007).

[49] EAA became connected with ESD, a company in the UK, starting around 1998 and changed its name to ESD sometime in the early 2000s. This then became ESDA sometime later.
[50] Otieno was invited by the committee to observe (Otieno 2007).
[51] It is not just fear, of course. The parliamentarians have institutional power to accept or reject policy (Otieno 2007).

The Energy Act of 2006 is not specific about the nature of the various intentions it states for renewables but there were practical implications, including a very large project to install PV systems in schools and health centres (Onyango 2007). However, the initiation of this Institutional PV Systems Programme was not due to the Energy Act; it actually began before the Sessional Paper on energy received assent in Parliament, which was a result, it seems, of presidential pressure following an electoral promise to electrify North Eastern Province (Mutimba 2007). According to Mutimba, the MOE decided to go with PV to electrify schools, despite a long-standing resistance within the ministry to renewable energies, because there was no other way to realise quickly the promises that the president had made during his election campaign. Onyango (2007) tells this slightly differently, claiming that the Permanent Secretary of the MOE was "the champion" within the ministry for the Institutional PV Systems Programme. Judging by the views expressed during interviews with some of the actors in Kenya, the former appears to be more likely: the Permanent Secretary was apparently well known for his objections to renewable energies and is said to have expressed his views publicly (Mutimba 2007; Otieno 2007).

Whatever the origins and motivations, the MOE started the programme with some pilot installations in one school (Onyango 2007). There were technical problems with the system, but these were fixed after the MOE employed a long-standing PV engineer – Kiremu Magambo – to consult on the project. Magambo also ran training sessions on PV systems for others in the MOE in preparation for the expansion of the programme (Onyango 2007). The programme got underway with invitations to tender and two rounds of this process had been completed by the time of this research (Onyango 2007). The money being spent by the Government on the programme is a significant injection into the PV sector. Up to the end of financial year 2006/7, the expected spend would be almost KES 257 million (USD 3.7 million approximately, using KES 70 = USD 1). For the next two years, the budgeted spend was to be KES 335 million (USD 4.8 million). Altogether, this would add about 514 kWp to the installed capacity in Kenya (Mbithi 2007:slides 12-18, and own calculations). These are additions of the order of 20% to 40% of the value of the household market (Mutimba 2007; Onyango 2007; own calculations). Indeed, there seems to be a more supportive policy environment for renewables in general, as evidenced by the budgets for energy reported in ROK (2007) (see Table 5.2).

However, there are mixed feelings about the Institutional PV Systems Programme. While it is being welcomed as a positive move in general, there has been some indication that it has raised the price of PV to the consumer and there are suspicions of corruption within the procurement process (Mutimba 2007). There have also been some issues over who can win contracts: despite an aim to include local technicians and companies in the work (Onyango 2007), in order to get a contract, a tendering company needs to have a 'secure' financial base and this limits participation to a handful of large companies (Rioba 2008).

Table 5.2: Expected output and outcome for the energy sector (KES 1000s)

	Estimate			Projected Estimates					
Programme	2007/08			2008/09			2009/10		
	KES (billion)	USD[a] (million)	%	KES (billion)	USD[a] (million)	%	KES (billion)	USD[a] (million)	%
Energy sector recovery	6.29	89.80	35.72	3.22	46.02	22.30	3.22	45.94	22.36
Energy efficiency	0.04	0.51	0.20	0.04	0.51	0.25	0.04	0.51	0.25
Rural electrification	5.74	81.97	32.61	5.74	81.97	39.71	5.22	74.62	36.31
Renewable development	3.47	49.54	19.71	3.97	56.78	27.51	4.48	63.96	31.13
Fossil fuel development	2.07	29.56	11.76	1.48	21.13	10.24	1.43	20.45	9.95
SUB TOTAL	17.60	251.38	100.00	14.45	206.41	100.00	14.38	205.49	100.00

Source: Adapted from ROK (2007:26, Table 4-0-0).

Note a: Calculated using KES 70 = USD 1.

5.7.4 Analysis of the energy policy making process

Both power and politics had important shaping effects on the recent niche developments we have discussed in this section. The Institutional PV Systems Programme was the result of *ad hoc* policy-making realised because of the power of the President's Office, and driven by the raised expectation among voters of electrifying their part of the country. And the official process of preparing a national energy policy became a political struggle with the unofficial process of the Policy Dialogue. The final outcome of that struggle – the Energy Act – was a compromise achieved through the exercise of the power of parliamentarians. Of course, these outcomes were not simply the result of power and politics: expectations, learning, networks and institutions – as SNM posits – were all involved as well.

The Institutional PV Systems Programme was initiated because of the expectation of electrification that the President had, it is claimed, collectivised during his election campaign. The only way that the MOE could realise this quickly was with PV systems. However, following years of neglect of renewables by the ministry, their internal capacity was poor. So, the MOE had to employ a niche actor to help them envision the expectation: troubleshoot their first system, design systems, train MOE staff, and so on. The impact for the PV niche was significant. While it created some big winners among those who won contracts, it also created some disquiet among other actors. In the case of PVMTI, disquiet stimulated actors to collectivise a new expectation and to seek a shift in policy. It is too soon to assess whether something similar will happen as a result of the Institutional PV Systems Programme, but there are some similarities in the conditions. There are large amounts of money available and the security of contracts for an extended period is attractive in what is often called a "cash-constrained" market. However, unlike PVMTI, there have been at least some winners under the programme so this may fragment any efforts to collectivise an alternative expectation.

The formal process of preparing policy, as we might anticipate, was a highly *political* activity; more so than the other activities we have studied. The number of interested actors, and the consequences at stake for them, was much higher than for other developments. The number of expectations and visions in play – often conflicting – was also much higher. We can consider a policy document to be, as with a standards document, both an envisioning and an institutionalising device. The fact that two policy documents for energy in Kenya – the MOE and the Policy Dialogue versions – were competing, served to intensify the political struggles. Of course, the MOE felt that their vision had more legitimacy, being an agent of an elected government; but the Policy Dialogue could also claim legitimacy as it had involved a much wider range of stakeholders than the MOE process. The outcome, as expressed in the Energy Act, was a compromise between these competing visions, whereby PV retained some recognition, as we have said, through the exercise of the power of parliamentarians.

Of course, the parliamentarians did not act spontaneously. Niche actors deployed socio-technical expectations in order to recruit their support and the parliamentarians, having experienced this second-order learning, began to adopt the detailed vision, expressed in the Policy Dialogue document, with the help of actors such as ESDA and GTZ. And ESDA and GTZ themselves experienced second-order learning as a result of their ‘success’ in influencing the Energy Act. For Otieno at GTZ, and the parliamentarians concerned, that learning was expressed in the formation of the Parliamentary Network on Renewable Energy and Climate Change: that is, the forming of an expectation that policy outcomes on renewable energies could be influenced through parliamentary actors, partially envisioned by employing ESDA to conduct seminars for those actors.

We can see that the interactions of niche actors with the regulatory and policy regimes were important for niche development in a number of ways. There were the kinds of outputs we might expect: technical standards, from interactions with the regulatory regime; an energy act reflecting some of the interests of the niche, from interactions with the policy regime. But there were other outcomes that were significant for niche development. The work on the standards committee stimulated the formation of KEREA. This has the potential to further articulate the networks within the niche and connect to networks beyond, as well as being an industry voice for interactions with government. It also created a code of conduct in addition to the technical standards, which could be important for institutionalising practice among the niche actors. And the policy experience was rich in learning for some of the key actors in the PV niche, particularly in terms of how to lobby and influence the policy regime. Clearly, if the niche has potential to become a regime itself then the knowledge created through this experience will be highly significant, and the parliamentary network development that ensued will be highly valuable.

5.8 Summary of the chapter

In this chapter we discussed the Kenyan case where, it appears, a household market for PV first emerged in East Africa. Burris and Hankins set about exploiting this, each taking his own role in the process. The training they did at Karamugi helped to disseminate the news that there was a household market beginning and, it seems, the Nairobi PV suppliers began to exploit it as well. Hankins went on to become a cosmopolitan actor through his work with EAA, managing many projects that helped to articulate the PV niche in both the ways we are using the term. Although it would be difficult to characterise the PV niche as having become a regime, we can see that there has been significant structuring, initially through the work of Hankins and others, but subsequently through the work of the standards body and, potentially through the policy regime, depending on how that develops. Having considered Kenya, the next chapter will look at Tanzania.

6 The Tanzanian Case Study

6.1 Introduction to the chapter

Having discussed the Kenyan case, we now turn to Tanzania. There was not much in the way of PV activity during the 1980s in Tanzania, unlike Kenya. We will review that period in any case because it is instructive as to why nothing really happened in the household market at the time. Much the same could be said about a significant part of the 1990s, although there were some important niche developments even if there was not much market growth. It was a period during which a few actors were trying to develop the market, albeit without success. Again, a review of the period is instructive for our understanding. Then at the end of the 1990s, we start to see more activity and from the early part of the 2000s, this really expanded very quickly. Soon after this, a number of projects with similar modes of operation got underway in Tanzania and now they cover much of the country.

As with the Kenyan case study, the empirical material is presented in either a thematic or periodic phase and then analysed before moving to the next phase. Because of this, there is overlap across all the sections in terms of time periods and activities. In each section, therefore, the discussion attempts to refer back or forward to other relevant discussions in this case or the Kenyan one.

6.2 PV experiences in the early years

From the evidence available, the early years of PV experiences in Tanzania appear to have lasted from the late 1970s up to about 1992. This 15-year period could be characterised as one of fragmented and widely dispersed activities, weakly connected to each other and to PV niche developments elsewhere. While there was interest among what we might refer to as policy regime actors in using the technology, and some private actors were supplying and installing PV systems, the dominant expectation concerning rural household energy needs did not include electricity. Rather, among policy regime actors, the focus of attention was on solving the problems associated with biomass use and substituting petroleum in the economy. For private sector actors, the dominant expectation seems to have been about donor-funded and infrastructural applications of PV systems. Consequently, there were few opportunities for learning that might stimulate the forming of an expectation concerning household PV systems, and only weak channels through which such an expectation might be collectivised. Given these conditions, it is difficult to identify something that we could call a PV niche in Tanzania during this period. Still, there were some activities and some actors engaged with PV: scattered seeds from which a niche might grow. This section sketches and analyses some of the activities of this period.

6.2.1 Scattered seeds

For much of the 1980s, the story of PV in Tanzania is mostly one of individual efforts, scattered projects and a few private systems. However, there was early interest in the development possibilities for solar energy in Tanzania. In 1977, the Tanzania National Scientific Research Council and the US National Academy of Sciences jointly organised a workshop, held in Dar es Salaam, to discuss the application of solar energy technologies at the village level (UTAFITI 1978). PV featured in the discussions as a competitive technology for water pumping and irrigation, when compared with diesel or petrol pumps (UTAFITI 1978:36-38; Williams 1978:119-130), but household applications were not considered.

Despite this early interest, very little was achieved on the ground. This lack of practical achievement may have had something to do with the official Tanzanian project-planning system. Sawe (1989:5) describes the system in detail, identifying twelve steps from the initiation of a project concept by a village government through to the funds being released by the Ministry of Finance, Economic Affairs and Planning. Each step in this process involved a level of the governmental apparatus where the concept was discussed, reviewed or approved before being passed on to the next committee or level. From the village, the project would be discussed at the ward level, then division, district, regional and then it would reach the Prime Minister's Office. From here, it would be passed to the National Economic and Planning Committee, then to Parliament and, finally, to the ministry to release the funds (Sawe 1989:5).

Nevertheless, at least some PV projects were implemented in Tanzania. GTZ supported a water-pumping project of the Ministry of Energy and Minerals (Sawe 1989:42), although Mwihava and Towo (1994:71) were able to document only 19 water pumps installed by the time of their research. The Expanded Programme on Immunization began using PV vaccine refrigerators in the mid 1980s but Mwihava and Towo (1994:75) only document two installations. And SAREC supported research into thin film PV fabrication at the Physics Department of the University of Dar es Salaam (Sawe 1989:53). However, the most substantial application for PV during this period was telecommunications. Tanzania Post and Telecommunications (TPTC) started using PV in 1981 and had installed 56.9 kWp of systems by 1994; and, from about 1988, the Tanzania Zambia Railway (TAZARA), Tanzania Railways Corporation (TRC) and Kilimanjaro National Park used PV for telecommunications and lighting (Mwihava and Towo 1994:69-70).

On the supply side, there were few companies active in PV. Possibly the first of these was Tropical Solar Systems (TROSS) in Arusha, started by Stephen Kitutu around 1983 or 1984 (Arkesteijn 2000:23; Mbise 2002:7; Kitutu 2008), although Kitutu was not actively marketing PV, and mainly installed solar water heaters (Kitutu 2008). In Dar es Salaam, BP Solar were selling PV, perhaps beginning as early as 1985 (Kimambo 2008) but certainly established by the end of the 1980s (Mbise 2002:7; Mwera 2008); and Intertec were supplying and installing systems by 1989 (Sawe 1989:7). According to Mwihava and Towo (1994:73-76), "the mainstay of BP Solar" was supply of domestic systems: indeed, BP had sold 147 of the 256 "domestic" systems identified in Tanzania, while Intertec had sold only four. And KARADEA, before becoming a PV supply-side actor as a result of implementing their solar project from 1993, received a donation of about 20 PV systems from Swedish Church Aid, and installed these locally in 1987 (Kasaizi 2008; Musa 2008a). Very few of these installations appear to have been accompanied by any training element. Mwihava and Towo (1994:71-72) attributed some of the failures of systems to this lack of training and local management, particularly for communally-operated water pumps, and so called for better training of local personnel to prevent such problems.

There were very few other developments during the 1980s. ESMAP conducted its first energy assessment mission and reported this in 1984 (ESMAP 1984). Some Tanzanians attended the masters training in renewable energies at the University of Reading: Kimambo found he was the third Tanzanian to take the programme when he went in 1985 (Kimambo 2008). The same year, the Ministry of Water, Energy and Minerals created the Renewable Energy Section (Mbise 2002:5) and Estomih Sawe was assigned to this as its Principal Executive Engineer (Mwihava and Towo 1994:94; Sawe 2008). Although there was interest in the ministry to implement PV projects, no money was ever secured (Sawe 2008). In any case, it seems that the focus of much of the work concerned with household energy-use was on biomass and overcoming the immediate problems in wood supply (Nkononi 1983). Indeed, it seems that the understanding within the ministry at the time was that electricity was something for urban areas, not a rural energy issue (Sawe 2008). Certainly, the first energy policy reflected the concerns over biomass, particularly the depletion of forests, while also devoting much attention to the issue of substituting oil-based fuels in the economy (URT 1992). As for electricity generation, this was to be achieved by exploiting the hydropower potential primarily, at various scales. In rural areas, biogas was seen as offering the greatest benefits for household cooking, heating and lighting. PV was mentioned in the policy but there did not seem to be any expectation that it would be used to any significant degree. Nevertheless, there was some governmental support for PV in the sense that the technology was tax-exempt for a short period: in 1990 the Government waived all tax on PV equipment but imposed an import duty of 5% in 1993 (Mwihava and Towo 1994:78).

The only other significant activities were the two surveys cited above: Sawe’s 1988-1989 survey of activities in Tanzania related to new and renewable energies; and the Mwihava and Towo survey in 1993-1994, which attempted to assess all types of energy projects. Both surveys covered all renewable energies and were, for the most part, cataloguing exercises. However, there were some recommendations suggested in both and these reflected a generally supportive tone regarding the appropriateness of applying renewable energy technologies in Tanzania. Further, both made points regarding the localisation of technology. In the case of Sawe (1989:39-40), this was to call for the deeper involvement of both local communities and the private sector in energy planning. Mwihava and Towo (1994:90) called for more involvement of local expertise, and an emphasis on standardisation. Both reports identified the need for more coordinated activity, and centralised information gathering to facilitate local analysis.

In terms of private sector actors, we can identify some others who entered the PV market in Tanzania during the 1990s. In Arusha, Swift Holdings began supplying PV equipment – mainly for donor-funded projects and to safari companies – in 1994 (Arkesteijn 2000:25; Mbise 2002:7); and Harold Burris came to Dar es Salaam from the UNDP-GEF Zimbabwe project around 1994, or perhaps as early as 1993, and was certainly doing installation work by 1995 through his company Ultimate Energy (Arkesteijn 2000:18; Kolowah 2008). Martin Saning'o – with technical assistance from EAA, and financial support from the Solar Electric Light Fund (SELF) and the Commonwealth Science Council (CSC) – had initiated the Orkonerei Solar Energy Project (OSEP) by 1995, or perhaps as early as 1993 (Nyaga 1996). Although this was a project within an NGO, and supported by donors, attempts were made to commercialise it, starting with the assistance of Thaguchi Nyaga from EAA in 1995 (Nyaga 1996).

As far as household systems are concerned, KARADEA, Ultimate Energy and OSEP were perhaps the most interested actors in Tanzania at the time, and through much of the 1990s. Their activities are discussed in more detail in section 6.3 below, following an analysis of the early period up to about 1992. Apart from these actors, a few other companies were present in the market from the late 1980s onwards – based in Dar es Salaam – but they were mainly selling and installing PV-powered water pumping systems (Arkesteijn 2000:22-23; Mbise 2002:7).

6.2.2 Analysis of scattered seeds

Up to around 1992, we can see that there was no collective expectation of household applications for PV and so no real attempt to focus resources in that direction. The dominant collective expectation for PV systems was the supply of village and community scale electrical services, such as water pumping, irrigation and vaccine refrigerators; and infrastructural support in telecommunications, railways, and so on. Considering that the actors who began discussing PV applications in Tanzania in the late 1970s were from the state sector and development regime, it is unsurprising that their expectations for PV systems were about community and infrastructural services. The understanding of rural household energy needs and practices (to the extent that there was some understanding) was primarily about biomass and kerosene, and the dominant development paradigm in Tanzania was about meeting basic human needs within the collectivist approach of Ujamaa.

Even the few private sector actors present in Tanzania appear not to have adopted any expectation of the widespread use of household PV systems. Kitutu was not actively marketing systems; neither were BP, despite *some* indication to them that household demand may exist. In Kitutu's case, perhaps this is straightforward to understand. He was working on his own with few resources, and the customers he *did* secure were wealthy. The overwhelming majority of the population were poor and dispersed widely, although there was an attempt to bring them together in *small* groups through the 'villagisation' policy under Ujamaa. With consumer electrical goods difficult to buy, PV modules expensive, and the dominant household practice of using kerosene for lighting (even among the wealthy), there was little that might indicate to him a significant demand for household PV systems.

In the case of BP it is a little more complicated. They had, at least, sold or installed an average of about three to four household systems per month (if we assume they started in 1989 and the figures for systems were from the end of 1993, that was 147 systems in three to four years). While this was not a large amount of business, it may have been surprising and so worth further investigation. Perhaps BP did consider getting more active or perhaps not. In any case, they continued to respond to demand, rather than attempt to create it, for many years afterward.

The other companies were focused almost entirely on larger systems and big contracts: water pumps, telecommunications, railway stations, parks, and so on. This 'project market' may have made a great deal of sense for them. They could base themselves in Dar es Salaam where they could establish contacts within the development regime and state sector, and do all their 'marketing' without risking much capital and spending much time on long and difficult journeys through the interior. With this expectation of a relatively simple business model, they only needed to focus on first-order learning: the details of establishing good contacts, importing equipment, the technicalities of making PV systems work in Tanzania, and so on. There was, understandably, nothing in their experiences to stimulate second-order learning from which they might form an expectation of a household PV system market.

So, the learning that appears to have occurred during this time was, perhaps, second-order in the late 1970s from which an expectation of PV systems for community and infrastructural services was created, followed by some fragmented first-order learning when disparate actors were involved in scattered projects. To the extent that any collectivising of expectations and learning occurred, it was through small networks of actors from a narrow range of organisations associated with the policy and development regimes. Private actors, while they may have had contacts within these regimes, were not well integrated into the policy and development networks; and the energy needs of householders were poorly understood.

In effect, there was no clearly discernible PV niche in Tanzania throughout the 1980s. It is possible that some of the private actors in Dar es Salaam exchanged information with each other, but there is no evidence for this. It is clearer that private sector actors were largely disconnected from those in the policy and development regimes, other than connection through the occasional contractual relationships for projects. There was no cosmopolitan actor, or group of actors, building broad networks and collectivising expectations or learning; or articulating a PV niche. Perhaps the most ‘natural’ cosmopolitan actor in Tanzania from the mid 1980s onwards – the Renewable Energy Section of MWEM – was sympathetic to the use of renewable energies but could not secure resources to either implement any substantial PV projects or facilitate any network-building. In any case, MWEM prioritised their efforts around biomass and petroleum-substitution.

Nevertheless, there were a few sites around the country where actors were experimenting with PV technology; learning to use it, understand it, and where to get it. And one of the projects that MWEM were able to implement – the survey by Sawe in 1989 – facilitated the identification of some of these actors and the cataloguing of their activities. This was a first attempt to articulate the niche, albeit in the descriptive sense, and may have helped Hankins when he made the journey through East and Southern Africa during which he tried to connect with others involved in PV. Certainly, the Institute for Product Innovation was mentioned in the survey and Kimambo, who soon after attended the 1992 Regional Workshop in Nairobi, was based there (Kimambo 2008). Harold Burris and a number of actors from Tanzania joined the Nairobi workshop as well, of course, including John Mwera from BP, Ngosi Mwihava from MWEM, Stephen Kitutu, Oswald Kasaizi and Martin Saning’o. So, in 1992, the scattered and isolated experiences with small PV systems of a broader range of actors in

Tanzania were brought together for what appears to be the first time. Perhaps, from the perspective of Tanzania, this was a niche-defining event: a broad range of actors working with PV, previously in isolation from each other but now able to connect, exchange information, and begin to develop ideas for further experiments. Moreover, the workshop included training on the installation of a PV system and so was, for some from Tanzania, an institutionalising event: an attempt to instil 'best practice' in small PV system installations; to collectivise expectations about PV systems; and to build networks and a constituency of PV actors.

6.3 Searching for a model

As already discussed in section 5.4.1, the 1992 Regional Workshop in Nairobi was useful to Hankins for immediately generating two projects in Tanzania. One was together with Oswald Kasaizi, the Executive Secretary of KARADEA, an NGO based in Karagwe District of Kagera Region – a particularly remote area in the north-west of Tanzania; the other with Martin Saning'o, who started his own NGO – Orkonerei Integrated Pastoralist Survival Programme (OIPSP)[52] – based in Terat, a village in the somewhat less remote Maasai Steppe, three hours south of Arusha.

However, there were other interesting developments that occurred during the period following the 1992 workshop, including the return of Harold Burris to East Africa from Zimbabwe. He came to Tanzania and set up a company – Ultimate Energy – in Dar es Salaam, where he began working with others to develop his business and develop the market. Perhaps the most important relationship he built with another PV actor in Tanzania was with the Tanzania Traditional Energy Development and Environment Organization (TaTEDO), who implemented a significant PV intervention that started towards the end of the 1990s.

This section describes and analyses these projects, with a view to demonstrating that the period was one in which actors were searching for a model of market development. Initially, this involved the transfer of a simplified form of the Kenyan experience but evolved through the implementation of projects that facilitated learning and network-building within Tanzania. While there was no significant market growth during the

[52] Orkonerei means approximately "dryland" in the Maa language.

period up to the end of the 1990s, these activities were useful for articulating a PV niche and providing a base from which later projects and enterprises would benefit.

6.3.1 An EAA model: catalytic capacity-building

The KARADEA project proposal was developed following a consultancy visit by Harold Burris[53] and Stella Katumi in December 1992. Hankins (2007) says that he did not attend at this time but the report suggests that he was indeed part of the consultancy (Burris, Katumi and Hankins 1992:8). In any case, he helped write the report and, as Burris had just been offered a post in the UNDP-GEF PV project in Zimbabwe, Hankins was asked by Peter de Groot of CSC to take on Burris' role in the KARADEA project (Burris *et al*. 1992:8; Hankins 2007). Kasaizi and Hankins then put the proposal together for an elaborate and ambitious project based around the idea of a Solar Enterprise Centre, encompassing a set of interlinked activities: a commercial solar business; training courses; development of affordable small systems; installation of demonstration business PV systems; and a credit scheme (Kasaizi and Hankins 1992:10). The Swedish Development Cooperation Agency (Sida) funded the construction of the building that contained a classroom and store, and possibly the PV equipment to get the project underway, while CSC funded the first training course in November 1993 (de Groot 1997:166; Kasaizi 2008). But not everything in the proposal was funded and so the project became focused more on training, with the result that the Solar Enterprise Centre became the KARADEA Solar Training Facility (KSTF).

Sometime during 1993, Frank Jackson, a trained electrician who had also studied photovoltaics at the University of East London, went to KSTF having been put in contact with them by Hankins, and Jackson persuaded APSO[54] (Agency for Personal Service Overseas) to fund his placement there as KSTF manager (Jackson 2008). KARADEA already had some experience with PV from the donations of equipment during the late 1980s; donations that continued beyond the initial 20 in 1987 to a total of around 50 by the time of the proposal (Kasaizi and Hankins 1992). That meant they had installed some systems, although they were not necessarily technically proficient. Still,

[53] Burris had left Kenya by the end of 1987 and had worked in various companies in the US (Hankins 2007). At the time of the consultancy with KARADEA, he was working as the Senior Engineer at the Virgin Islands Renewable Energy Institute (Burris *et al*. 1992:8).
[54] APSO was a volunteer organisation within the Irish Foreign Ministry but ceased operations during the 2000s.

it also meant that they had some experienced solar technicians and one of these, Gaspar Makale, went on to become an independent PV trainer in the East African region (Hankins 2007; Jackson 2008).

The first training course, led by Hankins and Kithokoi, was attended by technicians from Kenya, Uganda and Tanzania. At least one of the Tanzanians – Lukas Kariongi – was from Saning'o's NGO (OSEP 1998:22). The course was based on the one that had been developed through the USAID-supported three-schools project and the Nairobi regional workshop (Jackson 2008). As with both these courses, there was theory and practice over an intensive three-week period (de Groot 1997; Hankins 2007). There were many more training courses at KSTF – at least until about 2002 – and Jackson and Makale worked closely with Hankins and Kithokoi over the next few years to develop the material, format and organisation of the course. But, further, KSTF attempted to commercialise their activities around the Kagera Region: they installed systems for aid agencies in the Rwandan refugee camps and hospitals; sold solar lanterns; attempted to open battery charging stations in villages; and tried to source the equipment within Tanzania, usually from Ultimate Energy (Jackson 2008). Jackson left in 1996 but worked on PV in East Africa occasionally, and often with Hankins, for some years after this (Hankins 1998; Hankins and Jackson 1998; Jackson 2008).

In 1997, KSTF recruited their first Tanzanian manager, Mzumbe Musa (Musa 2008a; Jackson 2008). He managed the facility until mid 1999 when he left to do the MSc programme at Oldenburg. After finishing the masters he returned to KARADEA to manage KSTF, but moved to Dar es Salaam at the end of 2001 where he secured some work consulting on the initial phase of a UNDP-GEF project to be implemented in Tanzania (see section 6.4.3) (Musa 2008a). Before Musa left for the masters programme, he was one of the participants in a Training of Trainers course at KSTF. This was developed in conjunction with EAA and Jackson and the first one was held in 1998, wherein the trainees spent a short time learning how to train and were then supervised as they conducted training during one of KSTF's regular PV courses (Hankins and Jackson 1998). It is unclear whether any further Training of Trainers courses were run by KSTF (Jackson 2008) but at least two of the participants went on to train others: Musa and Bernard Osawa of EAA. However, KSTF did develop other kinds of courses, including a "solar orientation seminar" in 1999 and PV awareness days for the local community (Arkesteijn 2000:12; Kasaizi 2008; KSTF 2009). At the time of this research, the status of PV training at KSTF was unclear. Some of the established PV actors in Kenya and Tanzania expressed the view that there were no courses being run there anymore (Hankins 2007; Sanga 2008; Kimambo 2008; Sawe 2008). Certainly, donors had stopped direct funding of courses (Musa 2008a). In any case, up to 2004, they had trained at least 175 technicians on the intensive courses and a further 18 in three to six-month apprenticeships[55], as well as installing about 5 kWp of PV systems (KSTF 2009).

One of the reasons given for KSTF's 'demise' is that the facility is too remote[56], although this was considered a potential strength when the project was initiated: Hankins thought it would be a good showpiece because it would demonstrate PV in a place where it could really make a difference (Hankins 2007); and de Groot (1997:166) claims that:

> Our experience in Tanzania has shown that by holding the training in a rural area where some PV is used, we can successfully target students who intend to work in isolated areas.

Hankins continues to consider the KSTF project "a huge success", although he also sees it as "an example of how risky it is setting up infrastructure" (Hankins 2007). The project certainly received considerable donor support. Each course that EAA helped to conduct cost in the range of USD 20,000 to USD 25,000; the later courses conducted without EAA cost about USD 16,000 (Musa 2008). Together with the equipment costs of USD 100,000 to USD 150,000 (Hankins 2007), a total of up to USD 400,000 was donated[57] over a ten-year period.

The outputs are, in general, more difficult to quantify. We have already mentioned the number of technicians trained, but we could consider other outputs and impacts. There were early attempts to combine micro-finance with the sale of PV systems, based on KARADEA's experience of credit schemes with other technologies (Burris *et al*. 1992;

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[55] Jackson introduced the apprenticeship scheme and based it on the UK City and Guilds system of competencies. Each day an apprentice solar technician would be tested on at least one of the 'solar' competencies, gradually making their way through them all during their apprenticeship (Jackson 2008).
[56] Travelling from Dar es Salaam, for example, would mean three flights and then a long bus journey including, when I visited there in the late 1990s, crossing 'bandit country' with an armed police escort.
[57] These figures are not adjusted for inflation.

Kasaizi 2008); Makale worked as a technician there for over a decade and contributed to the training at KSTF as well as a number of other courses in the region; Musa developed his PV skills there and went on to work in the UNDP-GEF project in Mwanza (more on this in section 6.4.3); a number of people who went on to influence project designs and implementation received their first PV training at KARADEA; and, the course that was developed over a number of years became a model for other courses in the region. Perhaps the most significant impact the courses *failed* to achieve in Tanzania was to catalyse entrepreneurial activity once the technicians had returned home. Hankins (2007) talks of how Ugandans and Kenyans, upon their return home, got on with things right away, but this did not seem to happen in Tanzania.

Nevertheless, EAA conducted training courses in at least three other locations during 1996 and 1997. One of these, held in Arusha in April 1996, targeted local government district officers who might be expected to implement energy-related projects in their districts. The course was shorter than those at KSTF and included other renewable energy technologies, although it was perhaps biased slightly towards PV. EAA ran the course in conjunction with ApproTEC from Kenya and ETC from the Netherlands, and Burris demonstrated how to size a PV system and discussed how to conduct business in PV. And, in the same month, EAA conducted a training course at the Simanjiro Animal Health Learning Centre for which they repaired the PV systems that had already been installed by another local PV actor. As with the three-schools project in Kenya, the 1992 Nairobi workshop, and the KSTF training, the trainees received classroom-based theory sessions and then did the practical work (EAA-ApproTEC 1998). It appears that OIPSP may have had a presence on this course; certainly, this was the area in which the NGO was active (OSEP 1998:3).

Then, in October 1997, EAA installed a large number of small systems[58] at Wasso Hospital in a very remote part of Tanzania near to the Serengeti (Hankins 1998). Again, this was organised along similar lines to the other training courses: classroom-based theory and practical work to install the systems (Hankins 1998). Both Jackson (now ex-KSTF but funded by APSO) and Makale joined for the project (Hankins 1998; Jackson 2008). The installation was implemented as separate small systems rather than a single

[58] Hankins (1998:37) refers to the "support from several donors" for funding the project but does not specify who they were.

centralised system. According to Jackson (2008), this was intended to enhance the sustainability of the technology in that it was much easier to train local technicians to maintain a small 12 VDC system than to attempt this for a complex AC system with large battery bank, inverters and long cable-runs. Moreover, one system could fail without affecting others; a particularly important aspect for such a remote hospital.

6.3.2 Analysis of the EAA model

The KARADEA proposal brought together all the understanding that Hankins and Burris had developed over the preceding seven or eight years in Kenya into an integrated package for market development: a commercial element, a training element, a credit element, and the recognition that one of the PV markets could be for business uses. In this sense, the proposal articulated a new expectation: a sustainable PV market achieved through interlinked and interdependent activities that addressed local capacity to supply and support PV systems, in tandem with creating and enabling demand through demonstration and finance. Hankins had already written about these elements in regard to Kenya, particularly in his MSc dissertation, and may have seen an opportunity to apply his ideas and understanding of how the Kenyan market developed. However, as the project was only partially funded, not all the activities could be implemented as fully as the project proponents desired. In other words, we could say that an expectation was created of purposive market development but it was only collectivised among a handful of actors, none of whom had control over the resources necessary to facilitate the ‘full’ envisioning of this expectation through practice.

Even so, with Jackson managing the project, there was some attempt to envision and realise the fuller expectation. This resulted in first-order learning, as we would anticipate: learning what worked and did not work in terms of the technology in the field; who could buy systems and what they wanted from them; the details of working the apprenticeship scheme; the details of developing an infrastructure of supply; and so on. So, a vision of market development evolved, albeit slowly, and the evidence of market demand was enough to persuade Jackson that PV business was viable in Tanzania (Jackson 2008). This envisioning continued under Musa’s management, and there was further development in the form of KSTF-created courses and awareness-raising. We could see this as a new expectation created out of the experience of the

Training of Trainers course: a realisation and confidence that KSTF could run courses independently of EAA, hastened by donor reluctance to continue paying the high fees that EAA had to charge (Hankins 2007).

But the most significant impacts of KSTF relate to the training courses themselves. These facilitated considerable, and important, first-order learning for KSTF: the details of conducting training in such a context; and the details of the course content. We might assume that those who attended courses had already created some kind of expectation of PV, however vague, and that is why they were there for the training. The course then helped to articulate this expectation; to envision it through first-order learning. This was important because the trainees could bring the technical practices learned at KSTF to their own PV work, and they may have adopted the vision sufficiently that they had the potential to collectivise it among other actors. And, further, with the training attracting participants from across East Africa, there was network-building of a potentially rich quality: the participants were together for three weeks in a rural location “eating and sleeping solar” (Hankins 2007) so we can assume that at least some strong bonds were formed between participants, and that these may have enabled continued communications between them.

The aspect of network-building is particularly relevant when we consider the connections established through the solar orientation seminar given in 1999. That seminar was targeted at actors who could actually make a difference to project designs and implementation; perhaps the most significant of these being Finias Magessa from TaTEDO, who went on to manage TaTEDO’s first PV project and later became the Executive Secretary of TASEA. And, of course, EAA had tried something similar when they conducted the workshop in Arusha in 1996 for local government district officers: these were actors who may have been able to make a difference to project choices, designs and implementation on the ground. It is unclear whether any projects materialised from this attempt but we can interpret it as intended in this way, especially as one of the exercises was for each officer to sketch an energy project idea for their district (EAA-ApproTEC 1998).

Indeed, it is difficult to identify any significant impacts resulting from the three other training projects that EAA conducted. They are interesting from the perspective that they demonstrate further attempts to initiate PV activity in Tanzania. At best, we could speculate that the district officer workshop helped to raise awareness of PV in Arusha Region. The Simanjiro project trained technicians in the area, and may have been directly beneficial to OIPSP for this reason. Of course, the systems were beneficial to the learning centre and the centre would have acted as a demonstration of PV technology. Likewise, with the Wasso hospital installations, there was training of technicians and there were demonstration systems that were providing important services. From the perspective of the hospital, of course, the training was important so that the systems could be maintained, at least in principle. However, the most important outcome of these other training events may have been to do with the development of training itself. Those involved gained more experience conducting training and did so in new locations. For EAA, this helped to develop a training product and to add weight to their authority in the PV niches in the region, not just in Kenya: by conducting such intensive training courses, they were able to build networks in Tanzania through which they could develop a reputation. But, from the perspective of the niche, it is difficult to see any impact beyond a general raising of awareness.

Based on the interventions that EAA managed in Tanzania during this period, and the expressed frustration of Hankins (2007) that nothing seemed to happen in Tanzania after the training, it would appear that Hankins and others held or adopted an expectation that training would catalyse entrepreneurial behaviour among the trainees. This is most likely based on the experience in Kenya where this seemed to have been the outcome of the three-schools project, and was to an extent the outcome of the Nairobi workshop. That is, at the workshop, there was immediate talk about developing projects. However, such behaviour following the KSTF training was difficult to see in Tanzania. When we consider the conditions in the PV market at the time, this is not surprising. As the survey by Mwihava and Towo (1994) shows, the market was almost non-existent and there were very few private actors. The Tanzanian technicians may not have had a market demand demonstrated to them and so they may have only very weakly adopted the PV vision articulated in the training.

Nevertheless, KSTF were able to begin market development activities, partly because these were less costly and risky than for individual actors. Jackson was being paid by APSO and he was therefore able to focus on developing the commercial dimension of the project; something that would have been very difficult for a technician in Tanzania to achieve, not least because of the need to find immediate income sources. Moreover, for technicians from particularly isolated parts of Tanzania, setting up a business in PV when the suppliers were very distant would have been extraordinarily difficult. There was no secure supply chain so getting equipment would require collecting the cash for a system and then travelling by bus to Dar es Salaam to buy it. If the supplier had no stock then the technician would have to stay in the city searching for alternatives. Once the equipment was bought it would have to be transported by bus again back to the site for installation. One would have to possess enormous entrepreneurial energy and hold very deeply an expectation of PV business to undertake such an endeavour.

Even so, the KSTF experiment provided at least partial envisioning of the expectation that Hankins had formed when he worked on the proposal with Kasaizi. The market development work that KSTF did began to indicate that a market could be developed purposefully through an intervention. It was, as Jackson (2008) notes, moving very slowly but there was demand and it was possible to train local technicians to service it, as well as increase demand through demonstrations and some form of awareness-raising. In addition, some of the technicians who were trained at KSTF had the opportunity to practise what they had learned and so there was a degree of institutionalising achieved directly. Others may simply have carried the vision of PV to other parts of the country and not managed to do any more. For most, it is unlikely that they would have had the protection afforded by donor support that was available to KSTF and Jackson. With such protection, the project was able to begin a process of articulating at least the technician level of a PV niche in Tanzania that was connected to some extent with a regional niche. And the later connections to those who could make decisions about projects meant that the training approach was further institutionalised by many more actors.

6.3.3 OSEP and Ultimate Energy

OSEP (Orkonerei Solar Energy Project)

EAA were involved in a few other projects in Tanzania during the mid 1990s. As mentioned above, they began a relationship with Martin Saning’o at the 1992 Nairobi workshop and this was made more concrete by means of a solar lantern project supported by CSC and SELF, the aims of which were (de Groot 1997:167):

> … to demonstrate and evaluate solar lanterns and radio systems for a pastoralist community; to look at appropriate methods for marketing the systems on a sustainable basis; and to provide feedback to manufacturers concerning the acceptance and durability of their products in the field.

It is unclear exactly when this project began but it was certainly active during the latter part of 1995, and may have started in a small way as early as 1993 (Nyaga 1996:3). The project test-marketed three types of lantern – 5 BP-TATA, 7 Solux and 24 NAPS Magic Lanterns – and these were supplied through OIPSP's office in the village of Terat rather than through shops in Arusha, the nearest town (Nyaga 1996:3; de Groot 1997:167). There were three ways to purchase a lantern – 100% cash payment; 60% down payment, with the rest paid within three months; or payment in kind, such as with livestock or farm produce – and 25 lanterns had been sold by March 1996 (de Groot 1997:167). EAA then interviewed ten users about their experiences with the lanterns and how the products might be improved (de Groot 1997:167-168). People liked the quality of light of the BP unit, the radio connection of the Solux, and the long duration of light provided by the NAPS lantern in particular. While there was generally satisfaction among users, there were supply-side issues. The prices of the lanterns were raised considerably because of shipping costs and duties: the BP lantern, for example, cost USD 148 but was USD 258 after shipping and duties were included (de Groot 1997:167). And there was difficulty in operating credit facilities. Nyaga (1996:3), who was placed by EAA to assist OIPSP get the solar project underway, reports that it was a problem to collect the rest of the payment, saying that there were some customers:

> … who give an initial payment of say [10%] and then sit back, you have no way … to get more money … they pay at their own pace …

There were some technical problems with the NAPS unit. Nyaga (1996:3) reports that the module connection and the jack plug were prone to breakage, and this compared unfavourably with the Solux units in particular, some of which had been in operation for two years. Clearly, there were implications for the supply of spares, especially considering that the Solux lanterns were being assembled in Kenya within a German-funded project[59] suggesting, therefore, that they may be more sustainable.

In addition to the lantern project, a few larger systems were installed by the project (Nyaga 1996; OSEP 1998). These were quickly sold to individuals and used for a mix of applications: some were household systems; but some were for small businesses such as bars, or for community services such as lighting at a village centre. It was apparent, therefore, that there could be a demand for such systems. This may have been something of a surprise given that the Maasai were known as nomads. Indeed, one of the reasons for the interest in lanterns was that they were portable and would therefore fit well with the Maasai way of life. But, the market for larger systems was not pursued at this time. The placement of Nyaga at OIPSP was not long-term and his consultancy came to an end, probably during 1996. Still, OIPSP were interested in developing OSEP further and applied to APSO to fund a full-time coordinator.

In November or December 1997, Frank Jackson was employed by APSO to provide consulting services at the beginning of my assignment as the project coordinator. I had just returned from KSTF with one of the technicians from OSEP – Charles Memusi. I had observed the training and he had been a trainee. Jackson and the OSEP team, three technicians and myself, spent a few days visiting installations in the area, discussing what we wanted to achieve and developing a plan for how we would commercialise the project. Over the next three years we then attempted to do just this and some of the activities we attempted are reported in Byrne (1999).

We tried to encourage dealers in Arusha to stock PV equipment, although we were unsuccessful: Swift seemed completely disinterested; the BP office was similarly apathetic. We also marketed quite extensively to NGOs in Arusha, particularly the international ones. We would do this by arranging meetings to discuss PV and the skills we could offer. This led to some installation work and other people began coming to us for information. Likewise, we did free estimates for household systems, explaining what PV could and could not power. The number of people asking for information gradually increased, and some of these became customers. By the time Karlijn Arkesteijn (an

[59] This project later expanded to Lupembe and to Moshi, not far from Arusha. Because of this, OSEP tried, but failed, to form a connection to it.

intern with TaTEDO – see section 6.4.1 for more discussion of Arkesteijn's work) did her research for TaTEDO into the PV actors in Tanzania, we were getting about two enquiries per week (Arkesteijn 2000:13).

In terms of the technology, we tried to develop a very small system consisting of an amorphous module and car battery, designed to power two lights and a radio. It took some time to get the elements of this system together, but it became apparent to us that we needed to try to supply a system that was very simple: many of the homes in the area had just two rooms, and many people were using radios. The difficulty was with the charge controller; the cheapest on the market was USD 50, and had more functionality than was necessary for small systems. Instead, we designed a state of charge indicator that would give simple information about the charge remaining in the battery (Arkesteijn 2000:13). Once we had tested the system, and the news had begun to travel through the Maasai networks, we started getting enquiries specifically for this system. Although we sold and installed a few of them by the time I left the project in October 2000, it was too late for me to see if there would be any significant impact of such a development on sales, and whether users would learn to operate them.

We also tried to network with others in the country, and in Kenya. We had reasonably good connections with Burris (he already knew Saning'o and Kariongi) and we tried to buy some of the equipment from him. Later, through a course at KSTF in 1999, we became connected with TaTEDO (Magessa 2008). That led to further interactions, and other connections in what was now becoming a more networked niche: Sawe, Kimambo, Boniface Hanga (BP), Salvatore Mushi (Commission for Science and Technology – COSTECH), Mohamedrafik Parpia in Mwanza (retailer selling PV), Karlijn Arkesteijn and others. But we did not try to disseminate our experiences in written form. There was just one short article, written following a request from Moses Agumba of SolarNet, which was published in three places: in the *SolarNet* magazine, in TaTEDO's newsletter, and in a news section of *Renewable Energy World*. Rather, we tended to discuss our experiences with others: at meetings, social gatherings, seminars, workshops, and so on.

Ultimate Energy Limited

Burris came to Tanzania straight from working in the UNDP-GEF PV project in Zimbabwe, where he had been the Chief Technical Advisor. It seems that he did not stay long in the job: he had started in early 1993 in Zimbabwe and may have arrived in Tanzania before the end of the year (Kolowah 2008). It is unclear why he only stayed a short time in Zimbabwe, but he may have become disillusioned by corruption in the project (Jackson 2008). In any case, he was certainly in Dar es Salaam by 1994 and spent some time there before starting Ultimate Energy in 1995 (Arkesteijn 2000:18; Kolowah 2008). During 1994, he systematically trained Bughe Kolowah, a relative of Stella – Burris' wife – and an electrician, who had installed a couple of PV systems before he met Burris (Kolowah 2008).

So, Burris based himself in Dar es Salaam rather than in an area with easy access to cash-crop farmers; in Kenya, he had moved out of the city to the rural areas to be closer to the market. But he began to use some of the same marketing strategies. He networked with organisations and other actors; he demonstrated PV systems at the annual Sabasaba fair[60]; he distributed one-page brochures that gave some information about PV together with the company's contact details; some advertising in newspapers (both English and Swahili); and he attended a few workshops and conferences (Kolowah 2008). One of the workshops he attended was the training of district officers in Arusha, mentioned above in section 6.3.1.

He also continued to experiment with technologies; he even tested amorphous modules at his home in Dar es Salaam, despite their poor reputation at the time. After a short period (perhaps a few months), the film had begun to disappear from inside the lamination, and he never trusted the technology again (Kolowah 2008). He also continued to assemble lights, fabricate battery boxes and module mounts, and make DC to DC converters in his workshop. And, as he had done in Kenya, he trained his technicians to do the assembly work, as well as train them in PV (Kolowah 2008; Jackson 2008). Also, as had happened in Kenya, some of his technicians went on to start their own businesses: Francis Kibhisa started Rex Investments; Hamisi Mikate, together with another ex-Ultimate Energy technician, started Ensol; and Bughe Kolowah,

[60] Sabasaba is a popular agricultural show held on July 7th (saba saba is 7 7).

Ultimate Energy's first technician, started his own company on the advice of Burris (Kolowah 2008). And he made his designs for the balance-of-system (BOS) components available to everyone in the PV sector: KSTF used to hand these out during their training sessions (Jackson 2008).

He did installation work in most parts of the country, some of which was the result of the brochures he had his technicians distribute (Kolowah 2008). They tended to place these at bus stations and post offices; usually with the newspaper sellers. Some of the work was for household systems but the bulk was for organisations, and he later introduced power back-up systems for those in urban areas connected to the (unreliable) grid supply (Arkesteijn 2000:18; Kolowah 2008). According to Kolowah (2008), the business could be categorised as about 30% individual systems, 60% organisational systems, and 10% back-up systems.

Possibly as early as 1996, and certainly by 1998, Burris approached TaTEDO about PV. This led to the installation at the TaTEDO office in Dar es Salaam of their first demonstration system, based around a 33 Wp module (Magessa 2008). After this, Burris worked often with TaTEDO and was certainly present at some of the meetings they called when preparing to conduct their first PV training course in Dar es Salaam in 2000. It is highly likely that Burris had some influence over the design for this project much earlier, as he had got to know TaTEDO very well and tended to discuss his ideas for market development with all the PV actors he met. Moreover, he had direct experience of a large project from his time in Zimbabwe. The relationship with TaTEDO also led to his involvement with the first Tanzania Solar Energy Association (TASEA) committee (see section 6.4.3 for more discussion of TASEA), and to some important discussions with those involved in the Umeme Jua (see section 6.4.3) enterprise during its early stages (van der Linden 2008; van der Vleuten 2008). Indeed, Ultimate Energy was to be the technical partner in the joint venture but Burris pulled out of the agreement at the last minute, perhaps because he knew that he was very seriously ill (van der Vleuten 2008).

Besides his continuing experiments with technology and his extensive networking, which saw him connected to practically every actor in the PV niche in Tanzania and many elsewhere, Burris thought about alternative ways to deepen access to PV systems.

By 2000, he was considering two different approaches: fee-for-service and finance (Arkesteijn 2000:19). The fee-for-service approach would have been based on the Shell "smart system" technology, as used in South Africa[61] (Burris had become an agent for Shell); the finance approach did not seem to have been fully developed, although he had a basic idea in place for the scheme. As far as I am aware, he never managed to experiment with either of these approaches in Tanzania. Some other actors criticise the fee-for-service approach as unsustainable (van der Vleuten 2008; van der Linden 2008); while the finance approach was subsequently attempted by a number of others, mostly unsuccessfully (see section 6.4.3).

6.3.4 Analysis of OSEP and Ultimate Energy

There were two clearly identifiable collectivising and institutionalising events in the development of OSEP, both of which attempted to transfer something of the EAA 'model' of PV market development. The posting of Nyaga from EAA to consult on commercialising the solar lantern project was the first of these attempts; the second was the consultation with Jackson, together with my placement as coordinator of OSEP, following which we tried to operationalise that model.

We can infer a second-order learning experience when the first intervention was attempted. This created the expectation that solar lanterns were an appropriate way to get low-power electrical services into the hands of the Maasai, and that this could best be achieved using a commercial approach: demonstrate the technology to raise demand, make it available through a local supply system, and train technicians to manage the technology. There was then a flow of first-order learning experiences: the technical reliability and attractiveness of lanterns; desired functionality; willingness and ability to pay, and methods of payment; the impact of taxes on price; user-practices; the logistics of supply and service on the Maasai Steppe; the lack of business and sales capacity. There was also demonstration of demand for larger fixed systems, suggesting that there was a viable market for PV in the region. This may have been learning of a second-order quality in that the initial ideas for the project were based around lanterns because these appeared to fit well with the semi-nomadic lifestyle of the Maasai; the notion of

[61] Smart systems are solar home systems, where the payment for the electrical service is done beforehand, by using prepaid cards. One prepaid card allows the home system to provide electricity for one month (Arkesteijn 2000:19n7).

large fixed systems could then be seen as a new expectation for PV in this part of Tanzania. This learning was expressed in a report to EAA and CSC but does not seem to have been further disseminated, apart from a short paper by de Groot in *Energy Policy* in 1996 that focused on the lantern aspect of the project.

We can see the beginnings of the EAA market-testing methodology: getting technology into the hands of consumers and then asking them about their experiences. While Hankins tended to write extensively about such experiences, he does not seem to have written about this experiment. There also did not appear to be any networking activity beyond the use of the existing Maasai networks to disseminate the technology; not trivial in itself, but it is likely that these were relatively isolated from other useful networks. So, it seems that the learning that did occur was largely confined to those directly involved; there was little attempt to collectivise it beyond the project.

Nevertheless, OIPSP were able to use their experience of the project to persuade APSO to fund the placement of a full-time coordinator. This was in line with APSO’s policy that they intervene with capacity-building: I would work closely with a counterpart who would take over the coordinating role at the end of my assignment. And APSO contributed further with the Jackson consultancy. Here, again, we can see the influence of EAA, albeit less directly than the first attempt. Jackson had worked closely with EAA over the preceding three or four years trying to commercialise the KSTF project; and I had just observed a KSTF training course during which Hankins had discussed extensively the development of the Kenyan market and how to replicate this in Tanzania. So, the expectation within OSEP was profoundly shaped by the ideas of EAA, developed out of their understanding of the Kenyan PV market, vicariously envisioned to some extent through KSTF. We, as OSEP, then continued to be guided by this partially-envisioned expectation, detailing it further in the context of the Maasai Steppe. Much of the first-order learning we experienced was repetition of the learning that had been achieved earlier, although it was extended by greater networking efforts. However, as seems to have been the case with the earlier project, we did not actively disseminate our experiences beyond more or less casual discussions.

But, as Jackson had noticed while at KSTF, there was some indication of a market demand; it was slow moving but there was some information on which to begin articulating the market in the descriptive sense: the development of the small system articulated a segment of market demand to some extent. But OSEP were largely unsuccessful in articulating the local market in the connective sense, although there was some degree of success in making connections. Burris was an early contact for OIPSP; TaTEDO was a later contact for OSEP. Both were important in themselves but also in terms of the work and niche developments that flowed from these connections. For example, it was through activities organised by TaTEDO that TASEA was formed (see section 6.3.5), and the association provided a site for expressing and collectivising the learning that different actors had experienced in Tanzania. And, finally, the learning that the technicians in OSEP experienced was useful to them personally, even if the project itself ceased to exist. They were able to find occasional employed work[62] designing, installing and maintaining PV systems.

Burris' approach was somewhat different to the one he had used in Kenya. We might interpret this as the result of second-order learning. He did not set up business in a cash crop area; this time he based himself in the city. There were, perhaps, good logistical reasons for this. The cash crop areas in Tanzania were very far from Dar es Salaam, where much of the equipment was coming in to the country. If, as Jackson observed, Burris was the only real importer of PV equipment on a consistent basis, then he may have thought it better to be near the port. Trying to secure the supply of equipment while in a rural area far from Dar es Salaam would have been very difficult. By basing himself in the city, he could do the importing himself and perhaps supply to others, as well as having easier access to the 'project' market; a market he may have seen as the most readily available in Tanzania at the time. According to Kolowah's (2008) judgment, about 60% of Burris' work was through organisations; about 30% for individuals. So, Burris may have been forming an expectation of PV in Tanzania that was different to the one he held in Kenya. This one may have emphasised the business dimension more strongly. Whereas he had installed significant numbers of PV systems in homes in Kenya, he may have seen this as unlikely in Tanzania. Therefore, in order to do business in PV, he had to exploit the project market more fully.

[62] Two of the technicians – Lukas Kariongi and Charles Memusi – told me when we met during the field research that they have been able to get some work in PV since the project ended.

Alternatively, perhaps Burris was searching for a model with which to develop the PV market in Tanzania. The business he did in Dar es Salaam may simply have been a way to earn a living while trying to find ways to grow a larger market. It certainly appears that it took some time before he started doing installations. He used some of the same marketing strategies he had used in Kenya: meeting people; going to fairs; distributing brochures; and some advertising in the newspapers. And the approach to TaTEDO resulted in a small demonstration system. While this was in the city, and so not demonstrating PV to rural communities, TaTEDO were active as an NGO in the energy sector and well connected to actors in the development and policy regimes. Perhaps Burris understood that there was an opportunity for fruitful collaboration with them. The interaction certainly led to an important relationship that endured until his death. TaTEDO had their first PV system installed by Ultimate Energy and soon after began their first large-scale PV project. It is safe to assume that Burris contributed to these efforts through discussions with Sawe and others at TaTEDO.

Burris also continued to experiment with ways to widen access to PV systems, and to test new products. So, he was frequently forming new expectations, or adjusting those he already held, and tried to collectivise at least a few of these: the fee-for-service and finance of systems being two examples. He also experienced first-order kinds of learning on a continuous basis, and tended to collectivise this through his discussions with others. Not all of his ideas were adopted by other actors: he was opposed to the use of amorphous modules but most actors eventually made use of these. Amorphous technology was clearly attractive because of its price and this was an overwhelming consideration in the Tanzanian market. But, in terms of training, his influence was significant. This had been important in the initial courses in Kenya and these had formed the basis of the KSTF courses; he contributed to the design of the training courses developed by TaTEDO; and some of the many technicians he trained within Ultimate Energy went on to start their own companies in Tanzania. So, Burris helped to collectivise the learning he experienced in the Tanzanian context, and to institutionalise what he considered to be ‘best practice’. He helped to build, develop and maintain networks. And, he actively contributed to some of the technical innovations that were adopted by many for a number of years.

Neither of the two examples discussed here resulted in significant PV-market growth in Tanzania. But there were some important impacts on the PV niche. The OSEP experience provided some weak evidence of a market demand for household PV, particularly for very small systems, and there were indications that it was possible to purposively develop the market. Just as with KSTF, the opportunity to even investigate the possibility of a demand for small PV systems was available to OSEP because of donor-supported protection. It is surprising therefore that Ultimate Energy also investigated the possibility of small systems, given that they had no donor-supported protection. Burris brought a much wider experience to the niche, gained particularly in Kenya. He may have continued to hold an expectation of a household market from that experience and, together with the weak evidence he saw in Tanzania, he might have been motivated to try to develop the market. While the actors in both cases did not disseminate these lessons in written form, they did express them through discussions with other actors in the networks that were gradually developing in Tanzania. And both actors appear to have been sufficiently convinced of some kind of market development model that they continued to express it through the training courses in which they were involved, thereby helping to collectivise the expectation and institutionalise the practices they understood were necessary to support the sustainability of the approach.

6.3.5 TaTEDO PV projects

Estomih Sawe continued working for the Ministry of Energy and Minerals until 1996 when he moved to take over the role of Executive Director at TaTEDO, which he did initially on one year’s unpaid leave from MEM (Sawe 2008). During his time at the ministry he was involved in some significant energy projects including a major World Bank project focused on biomass, and a project funded by Sida focused on capacity-building in participatory rural appraisal (PRA). During the World Bank project, in 1989, Sawe, the World Bank consultant to the project, and others, hatched the idea of creating a Tanzanian NGO that would help build local capacity for energy interventions in order to improve the sustainability of such projects. In 1990, TaTEDO was officially registered.

After Sawe started working at TaTEDO he initiated their PV activities. Part of the reason for TaTEDO’s branching into other technologies may be because of an evaluation conducted by Dominic Walubengo, who recommended that they include energy issues other than those around biomass (Sanga 2008). And, sometime during the period 1996 to 1998, following the approach of Burris, they installed a small PV system at their office in Dar es Salaam (Sawe 2008; Kolowah 2008; Magessa 2008). During 1998, Sawe and others from TaTEDO, together with consultants from Hifab International, conducted a PRA study for Sida of energy needs in rural areas. The purpose of the study was to (Hifab-TaTEDO 1998:3):

> … provide background information for formulation of project proposals to improve energy services for people in rural Tanzania in a sustainable way. Conditions to the energy projects were that they should be environmentally acceptable, gender sensitive and favour renewable energy sources.

The study identified a number of reasons for the under-use of renewable energy technologies in the rural areas of Tanzania: lack of awareness and information; no demonstration systems; few training possibilities; poor infrastructure and framework for energy services; lack of credit facilities; and immature market behaviour (Hifab-TaTEDO 1998:5-6). Whether the study results contributed directly to proposal writing in TaTEDO is unclear but, soon after the study was published, they were awarded funding by Hivos and Norad for a large PV project that included awareness creation, training, demonstration systems, networking, and market development (Arkesteijn 2000:4-5). The project was to run from 1999 to 2002 (Sanga 2008), covering three regions: Dar es Salaam, Mwanza, and Kilimanjaro; chosen because of their poor grid infrastructure, potential for renewable energy use, and the strength of the local cash economy (Arkesteijn 2000:4).

TaTEDO initiated a phase of internal capacity building in which Finias Magessa was sent to KSTF on two occasions: first to attend the basic installation course, in 1998, and then to attend a specially-designed course for ‘policymakers’, conducted around March 1999 (Magessa 2008). It was here that I first met Magessa, and I was invited, along with Gaspar Makale from KSTF, to contribute to the design of the training courses to be implemented in their up-coming regional PV project. The first of these courses was conducted in Dar es Salaam in May 2000 and immediately afterward there was a National Stakeholder’s Workshop, involving the trainees, trainers, and a number of other actors from the private and public sectors (Arkesteijn 2000:10). It was clear during the final meeting at the workshop that the training course had raised considerable enthusiasm among the trainees. This generated discussion of ideas for ways to maintain contact and share information, eventually leading to the creation of the Tanzania Solar Energy Association (TASEA) (Magessa 2008). An executive committee was formed immediately, including Kimambo (Chair), Sawe (Secretary), Burris, and myself (Arkesteijn 2000:48). Others were elected soon after and we began to have regular meetings in Dar es Salaam to decide the form of the association, what it should do and not do, and so on. There is more discussion of TASEA in the section covering the Sida-MEM project (see section 6.4.3), as it was from this project that TASEA received substantial financial support.

TaTEDO then began conducting their training courses outside Dar es Salaam, the first of which was in Mwanza in August 2000 and the second in Kilimanjaro Region later the same year (Sanga 2008). Each course ran for two weeks and was very similar to the KSTF training: there was classroom-based theory, practical exercises, and PV installations at a real site. Many of the participants came from partner organisations of TaTEDO's, the hope being that they would include PV activities in their own programmes once they had received the training (Sanga 2008). However, in the Mwanza training, there were at least a few from local dealers who were selling PV equipment; most notable, perhaps, being Mohamed Parpia[63] of Mona Electrical and Electronics in Mwanza town (TaTEDO 2000:11). At the end of each training course, there was a stakeholder's workshop and TASEA was publicised during this as a way to increase the membership. The installations acted as demonstration systems – one of the elements of the overall strategy – covering a range of applications such as in dispensaries, schools, village offices, and some households (Sanga 2008). The first of these, installed during the Dar es Salaam training, involved a number of systems to power lights and radios at a youth centre (Arkesteijn 2000:9-10).

Before the second round of training courses started – to be held in the same regions – TaTEDO found that "very few of the trainees [who had been on the first round of courses] could use their knowledge in their programmes" (Sanga 2008). As a result, TaTEDO decided to target those who were already working in PV companies, or who

[63] Parpia became very active in PV, later became the Chair of the Mwanza branch of TASEA and, in 2007, won the Ashden Award for Sustainability.

demonstrated promising entrepreneurial energies. For the second Mwanza training, they used the Vocational Education and Training Authority (VETA training facilities and included a number of VETA staff as participants. One of these was a teacher who was “very serious” about the training, and this led to the development of an officially approved PV course that VETA could run itself (Sanga 2008).

A second project continued the work of the first, running until 2005, but was focused more on building technical and entrepreneurial capacity (Sanga 2008). There was then a pause in TaTEDO’s PV project implementation, during which there was an assessment conducted by the Norwegian donors. In 2007, another project was started, funded once again through the Norwegian Embassy. This project intended to build local government capacity, to feed into the policy process; to experiment with finance, which appeared to have been missing from the first two projects; to focus on larger systems such as those in schools; and to develop productive-use applications, such as mobile phone charging stations (Sanga 2008; Sawe 2008). However, we will not discuss this project further as it was beyond the scope of this research.

6.3.6 Analysis of TaTEDO projects

We can see that the formation of TaTEDO resulted from second-order learning achieved during discussions between Sawe, the World Bank consultant to MEM, and others. This created a new expectation of an NGO working to build local capacity and enhance sustainability in the energy sector, rather than the perceived over-reliance on external actors and the Government. We might assume that those in TaTEDO then experienced mostly first-order learning as they developed their ability to implement projects, get funding, conduct training, and so on. They also began building networks as they cultivated relationships with partner organisations in the country; other NGOs in particular. Sawe then brought his experience of projects, and connections with actors in the development and policy regimes, with him when he took over at TaTEDO. He also had a broader interest than biomass and soon introduced projects around other technologies. For the organisation, then, this might be seen as the creation of a new expectation: second-order learning stimulated by Sawe’s ‘bid’, perhaps supported by Walubengo’s evaluation, and certainly justifiable after the rural energy study for Sida.

As the Executive Director of TaTEDO, of course, it would have been relatively easy for Sawe to collectivise his personal expectation among actors within the organisation.

There was some initial learning with PV after they had their first PV system installed by Ultimate Energy. This was then enhanced when they began their internal capacity-building phase with Magessa's training at KSTF. By this time, of course, Magessa already held an expectation of PV in Tanzania so learning was essentially an envisioning process for him. And TaTEDO had secured funding for their first large-scale PV project. This would have involved a proposal that may have articulated some reasonably detailed expectation – perhaps a vision – of widespread dissemination of PV systems providing electrical services to rural Tanzanians. Whatever the quality of this expectation, the implementation of the project began the process of envisioning it more fully, as well as collectivising it for those actors involved. One important early indicator of the collectivisation process was the formation of TASEA: again, a new expectation created out of discussions among actors, even though many of these were trainees and so only beginning to adopt a PV vision as expressed by those presenting on the course.

Learning then took place through the experience of conducting training courses in the three regions on which the project focused. We would anticipate that there was learning for the participants: this may have been a mixture of first and second-order qualities of learning, although we might assume that they had at least adopted an expectation of PV to some extent. The training itself may have helped to establish the expectation more firmly in the minds of the trainees, with some envisioning achieved through the classroom and practical work.

From the niche perspective, there was learning about the effectiveness of the training. Sanga (2008) notes that TaTEDO realised, after the first round of regional training in Mwanza and Kilimanjaro, that they needed to select trainees using different criteria. Most of the trainees on the first round of courses were unable to use their PV training once they had returned to their organisations because none of the organisations was active in PV. The second round of training therefore targeted those already working in PV companies, and incorporated more on the business or entrepreneurial dimension. This was a challenge to one of the assumptions of the project. That assumption was that the trainees would use their knowledge to develop projects and activities within their organisations. But none of the trainees was in a position to initiate such activities except for those who were already working in PV: Parpia, for example, was able to make use of his training.

So, TaTEDO began to realise that they needed to connect to different kinds of actors: more from the private sector should be trained; and the training needed to be more firmly institutionalised, hence the connection to VETA, an actor in the education regime. Moreover, reflecting this shift in the training aspect of the expectation, the content needed to emphasise business and entrepreneurship. These elements, in particular, had been assumed to be somewhat automatic responses to the technical training: that technicians, once trained, would immediately start their own businesses in PV. This was an aspect of the earlier expectations influencing interventions at that time, persisting into these newer experiments. The lesson seems to have been learned this time because there was some follow-up on the initial training. Having found that almost no-one was active in PV except those in the shops selling equipment, the response was more or less obvious. Within the training dimension of a broader vision for PV in Tanzania, this was something of a second-order learning experience. This was a new expectation for training partially envisioned by answering the questions: What is the training for? Who should be trained? What kind of content should the training therefore include and exclude?

There were further implications that flowed from this new expectation. TaTEDO now began to extend their network much more beyond NGOs, and the policy and development regimes; particularly to include more private sector actors. In turn, these provided a wider base of support for the fledgling TASEA, as each training course included a pitch to join the association: the further collectivising of the expectation formed around the organisation, and further network-building. And TaTEDO were becoming an important cosmopolitan actor in the PV niche in Tanzania: identifying new actors, developing links between actors, institutionalising practices, initiating activities, disseminating information, and securing resources. We might see EAA’s first attempts in Tanzania as cosmopolitan activities but these were not as intense, nor as frequent, as those they conducted in Kenya. TaTEDO, on the other hand, were only engaged with activities in Tanzania and so could be much more focused.

It is interesting to note that the project TaTEDO managed to get funded in Tanzania had some of the elements of the original idea expressed in the KSTF proposal. It was not exactly the same, but it was similarly integrated: both included creating awareness, or raising demand; installing demonstration systems; experimenting with finance; and conducting technical training. In terms of differences, the KSTF proposal was more explicit about developing supply chains; while the TaTEDO project included lobbying for enabling policy. The supply chain strategy in the KSTF proposal was long-advocated by Hankins (Jackson 2008); while the policy element in the TaTEDO project may have reflected Sawe's confidence that the policy regime could be influenced by non-regime actors, perhaps based on his understanding of the policy regime and his strong connections to it.

6.4 Articulating the Market

There had been a few surveys of PV activities in Tanzania, and there had been an appraisal of energy needs in rural areas, conducted during 1998 for Sida. But no-one had specifically studied the actors in the PV market and their network relations, neither had there been any market surveys. Beginning in 2000, there was a flurry of such studies associated with various planned interventions. Karlijn Arkesteijn, an intern with TaTEDO, conducted an actor analysis of the PV market in 2000; EAA, together with TaTEDO and Ameco Environmental Services (a Dutch consultancy), conducted a series of market assessments in 2002 intended to provide business information for the Umeme Jua joint venture that had just got underway (see section 6.4.3); and TaTEDO and Fredka International (a Tanzanian consultancy) conducted a baseline survey of the PV market in Mwanza in 2004 for the UNDP-GEF project that had recently started there (see section 6.4.3). So, these studies formed the first attempts to comprehensively articulate the PV market in Tanzania, in the descriptive sense.

They all tended to come to similar conclusions and to characterise the market in similar terms, although each contributed new information as well. Consequently, we will not analyse them individually; rather, we will discuss them in an integrated way, attempting to describe their more useful aspects and analyse their more important implications for niche development.

6.4.1 Surveys and studies

Karlijn Arkesteijn came to Tanzania in March 2000 to work as an intern at TaTEDO (Arkesteijn 2009). She had been asked by Frank van der Vleuten, of Free Energy Europe (FEE) at the time, to conduct an actor survey of the PV market using a RAAKS methodology: Rapid Appraisal of Agricultural Knowledge Systems (van der Vleuten 2008; Arkesteijn 2000). The reason for van der Vleuten's request was that he was interested in FEE entering the PV market in Tanzania (van der Vleuten 2008). FEE were already selling their amorphous modules into the Kenyan market, where they were using the dealer network of Chloride Exide. Having visited Tanzania during the late 1990s, van der Vleuten wondered why he could see no evidence of a PV market when there was one thriving next door in Kenya. He already knew TaTEDO from work he had done with the Energy Research Centre of the Netherlands (ECN) and ETC on energy in developing countries and had placed a Dutch engineer – Marcel van der Maal – with TaTEDO to work with them and to test the idea of supplying FEE modules into Tanzania. Essentially, these were the first few steps towards starting some kind of commercial enterprise in the country. That enterprise became Umeme Jua (a Dutch-Tanzanian joint venture), which we will discuss in more detail in section 6.4.3.

Arkesteijn spent about three months – April to June 2000 – researching the study and travelled to Mwanza and Kilimanjaro Regions, as well as interviewing actors in Dar es Salaam (Arkesteijn 2000). She tried to capture actors from all sectors who might be considered stakeholders in the PV market including religious organisations (they were some of the first to install systems in the country), TaTEDO's partners, public sector, PV companies and small businesses, and financial institutions. Following the interviews, she mapped the relationships between the various actors within each region using linkage matrices and analysed the linkages across the regions. The analysis revealed very poor links between actors in the Kilimanjaro Region, and likewise in Mwanza (Arkesteijn 2000:41-43). Dar es Salaam had some very strong relationships, such as the link between TaTEDO and Ultimate Energy. Across regions, there were few relationships but TaTEDO were the best linked of all the actors surveyed (Arkesteijn 2000:43).

Besides interviewing the actors about their activities in the PV sector and the qualities of interactions with others, Arkesteijn asked them to explain how they thought the PV market could be developed. An overwhelming response was that there needed to be some kind of central actor who could coordinate information and knowledge exchange. Beyond this, all the issues identified in the 1998 rural energy study were mentioned: lack of awareness of PV; difficulty sourcing equipment; lack of standards; taxes too high; not enough training; financing was needed, and so on (Arkesteijn 2000:45-51). So, despite their relative isolation from one another, most of the actors were converging on the same set of issues that needed to be addressed if the market were to develop.

The Umeme Jua venture began preparations in Tanzania during 2001 and started officially sometime in 2002 (van der Linden 2008). During this time Umeme Jua commissioned EAA, TaTEDO and Ameco Environmental Services to conduct a series of market surveys. The regions chosen were Dar es Salaam, Arusha, Morogoro, Mbeya and Mwanza. Sanga was involved in at least three of these for TaTEDO, working with Hankins for the first survey in Dar es Salaam, with Arkesteijn (Ameco) for the survey in Mwanza, and with Osawa (EAA) for the survey in Morogoro (Sanga 2008).

The methodology included an overall view of the socio-economic situation in the region, and interviewing householders in a number of villages and in the urban centre (EAA, TaTEDO and AES 2002a, b, c, d). Also, in the urban centre, potential dealers were identified, some of whom may already have been selling PV and associated products. Past experience with PV in the region was assessed; wealth, and willingness and ability to pay were assessed by analysing assets purchased (radios, TVs, cars, bicycles, refrigerators, mobile phones, and so on); and awareness of PV was investigated. Both householders and retailers were asked about interest in buying: in the case of retailers, this was about how many enquiries for PV they received. The local infrastructure was described: road and rail links, condition of the local road network, schools, hospitals, and so on. Battery charging stations were included as an indication of the demand for low power electrical services. And seminars were conducted for businesses during which they were presented with the commercial opportunities in PV (Arkesteijn 2009). Sanga (2008) notes that the methodology was clearly familiar to Hankins and Osawa, indicating to him that they had used it before.

The same constraints were found in every region studied: low awareness of PV, low technical and business capacity, poor supply of components. Where PV was on sale, the prices were found to be substantially higher than in Dar es Salaam. In some places – Mwanza and Mbeya – modules were being smuggled in from Kenya, and Zambia or Zimbabwe respectively, so as to avoid paying duties and VAT. In Mwanza, some of the dealers were not advertising because they feared they would then attract the attention of the Tanzania Revenue Authority. As Arkesteijn found in her study in 2000, what networks existed were poorly connected within themselves and to others. Retailers tended to have their own supply systems and agreements with companies in Dar es Salaam or elsewhere so there was no bulk purchasing or sharing of information.

In a more active sense, the surveys were trying to identify potential partners for Umeme Jua in the surveyed regions. One that came through strongly, in the regions in which they were operating, was Tunakopesha – a hire purchase company – and they did become an important partner (and subsequently a competitor) of Umeme Jua (van der Linden 2008). Indeed, the surveys provided the first database of dealers that Umeme Jua used (Arkesteijn 2009). And, a new market was identified: a migrant worker[64] market; something "Hankins and his team discovered, unknown to us when we did the [Umeme Jua] proposal" (van der Linden 2008). Moreover, this later offered a more steady demand than the farmer-based market where income was seasonal.

However, while the surveys seem to have presented quite comprehensive information about the markets in the study regions, and Umeme Jua made use of the dealers identified, van der Vleuten (2008) states that they did not provide the kind of information he needed. Instead, he wanted to know who the right actors would be in each of the locations. To achieve this, he developed a basic set of questions that could be answered in a one-minute visit to a shop, for example: What condition is the shop in? Is the owner just counting money? Are there many customers in the shop? And so on. He used this later in the Free Energy Foundation project, discussed in section 6.4.3.

[64] Migrant workers were working in urban areas away from their rural homes. Some of them had disposable income that they used to buy goods for those rural homes.

The TaTEDO-Fredka study was conducted as part of the preparations for the intended UNDP-GEF project (see section 6.4.3) to be implemented in Mwanza Region, with the main objective to (TaTEDO-Fredka 2001:2):

> … provide background information for formulation of awareness raising and human resource plans for solar PV market development in Mwanza Region.

So, there had already been an assessment that there were barriers to market development in Mwanza Region, two of which were low awareness and inadequate human resources to manage the technology. The survey, covering seven districts and a total of 389 respondents, used a complex methodology involving interviews, observations, PRA, documentary evidence, and a stakeholders' workshop (TaTEDO-Fredka 2001:5-7).

Low awareness and human resources needs were assumptions at the beginning of the study so it was no surprise that these were indeed observed in the study findings. However, many other issues were identified and these were consistent with the other studies conducted during the previous three or four years. However, in addition to this general agreement with other research, the study gave detailed and fine-grained descriptions of where the awareness was low, who was not aware, where the human resource needs were, what these needs were, and so on. It also discussed issues to do with the policy environment, taxes, standards and codes of practice, financing and the constraints of the Tanzanian regulations, poorly functioning supply chains between the urban and rural areas, weak networks, and so on. Essentially, these were the same issues that had emerged from the previous studies and surveys. This enabled the formulation of a highly detailed set of plans to address these problems. The roles of different actors, objectives, methods to achieve objectives, target groups, resources, timeframe, and so on, were all assigned or identified.

6.4.2 Analysis of the surveys and studies

Much of the learning in the surveys was of a first-order kind. This is unsurprising in that the starting point for any of the surveys might be characterised as a problem-expectation. That is, a degree of second-order learning has already occurred sometime in the past to form an expectation of what would be useful or important to study in more detail. The purpose of the research is then to fill in that detail; to articulate a problem-vision.

Arkesteijn's actor analysis began from the expectation that actor knowledge systems, and the way actors exchange knowledge with each other through networks, are important for understanding, in this case, the PV market in Tanzania. This problem-expectation then guided her in detailing a problem-vision: an articulation of the PV market and the means by which it could be developed. One of the most striking findings was just how disconnected the 'networks' of actors were in Tanzania. There were several small networks of actors who rarely exchanged information within their respective networks, weakly connected with the other poorly functioning networks. Consequently, there was little learning from the activities of others, and significant potential for duplication of effort and mistakes.

TaTEDO emerged as one of the best placed actors because they were beginning to address this network issue through their regional PV project. Likewise, the benefits of an actor such as TASEA were now obvious. This kind of learning had been achieved in the rural energy study in 1998 but Arkesteijn's analysis expressed the problem in very specific detail, showing which actors were connected and disconnected, and the quality of those connections. However, the study was not entirely passive. By conducting the research, Arkesteijn discovered actors who were either somewhat unknown or completely isolated from everyone else, and connected some of them into the niche-network, to the extent that it existed. Further, she sought to connect actors from the finance regime. In other words, her study had some network-building impact and attempted some regime-linking.

Apart from this learning, her survey tended to reinforce much that was discovered in the rural energy study, extended to include problems more specific to PV: lack of information and awareness; market constraints; the impact of taxes; technical problems; the lack of coordination or coherence. But Arkesteijn also documented something of supply-side practices: target markets, marketing strategies, sourcing of equipment. And she articulated the thinking of PV actors in regard to their expectations for the PV market in Tanzania. The lack of coordination – a role for a cosmopolitan actor – was clearly a felt need among many. However, something the survey did not manage to articulate was any market demand, at least not in any 'objective' sense. Instead, there were some articulations of market demand as expressed by the actors from their own perspectives. Still, Arkesteijn herself detected such a demand having done the research, to the extent that she was "convinced" of it: that is, she formed a personal expectation of a PV market in Tanzania (Arkesteijn 2009). This was difficult to collectivise because it was not articulated but it was shared by van der Vleuten. He had asked her to do the study partly because he already held this expectation to some degree.

The surveys conducted by EAA, TaTEDO and Ameco, were based on a methodology already familiar to EAA. For TaTEDO, and perhaps Ameco, there was some learning during the implementation of this in the field. These surveys, unlike the Arkesteijn study, were intended to evaluate market demand; to articulate demand highly specifically. So, at the general level, the learning was about potential demand for PV systems. This was not demonstrated demand but an indication of the kinds of potential customers and the size of the market, given in watts-peak. All of this was first-order learning in that these were indicators already chosen before the surveys were conducted, based on knowledge and experience elsewhere. So, the survey design was based on an expectation of who PV customers would be, dependent on their practices as already understood from the experience of markets such as Kenya.

The surveys articulated the same problems found in the rural energy study and the Arkesteijn survey: low awareness of PV, low technical and business capacity, poor supply of components, and weak networks. In some places modules were being smuggled in to the country. This was to avoid duties and VAT. In Mwanza, some of the dealers were not advertising because they feared they would then attract the attention of the Tanzania Revenue Authority. This was interesting because the 1998 rural energy study had found that some actors did not advertise even though they had benefited from doing so in the past (Hifab-TaTEDO 1998). Here was a potential explanation for what had seemed like a strange practice.

So, there was learning about various supply-side practices, and there was learning about the extent of expected demand-side practices. Moreover, with the large number of households surveyed overall, the results were a significant articulation of the PV niche, providing evidence on which to collectivise expectations and make business decisions – to persuade investors to commit resources.

The survey methodology included seminars to explain to potential dealers more about PV. In this sense they facilitated some network-building. It is not apparent whether this was significant at the time, but they did seem to capture the attention of Tunakopesha. They later became an important partner for Umeme Jua and subsequently an important competitor. And one of the aims of the Umeme Jua strategy was to make use of existing distribution networks. To the extent that we could characterise the retail sector as a regime, the Umeme Jua strategy included creating links with that regime.

The TaTEDO-Fredka study was focused on Mwanza and was to articulate a vision for addressing the barriers, as they were already identified, of low awareness and inadequate human resources. In other words, as we discussed above, the study began with a problem-expectation and was meant to articulate a problem-vision. This would then enable the elaboration of plans to solve the problems – remove the barriers, to use the language of the report. And, once again, the articulation of the problem-vision was similar to those in the previous studies. It was about lack of awareness and human resources, of course, and so it detailed these problems. But it also identified poor networks, the problem of taxes and lack of enabling policy environment, the lack of PV standards and codes of practice, the lack of formal training courses, and the constraints of the finance regime. The problem-vision it articulated was highly prescriptive, as we would anticipate given that it was meant to produce a plan of action. A wide range of activities and actors was detailed, timescales outlined, methods described, indicators identified, and so on. In short, it was a clear vision of how to develop the PV market in Mwanza Region, in regard to two dimensions of the problem.

So, taken together, these surveys articulated in fine detail, and over five regions, a problem-vision of the PV niche and PV market in Tanzania during the period 2000 to 2002. The effect was to generate learning about the niche that had not been achieved previously. Niche actors could now understand with confidence how the market was functioning and how it could be developed. The extent and characteristics of market demand were articulated, providing information on which to make investment choices; and many of the dimensions of the niche trajectory were articulated, providing information on which to make intervention decisions. Indeed, the studies were commissioned precisely for these reasons. The next section discusses the interventions that ensued, and analyses their impacts on the niche.

6.4.3 A flurry of PV experiments

The TaTEDO projects that began in the late 1990s had accelerated niche development across three regions of Tanzania. And the various studies and surveys contributed to this process. This work built on the earlier scattered and fragmented efforts of others and laid a foundation on which a number of other interventions themselves built over the ensuing years. Altogether, there were five large-scale projects implemented, the first of which started in 2001 followed by a flurry of projects starting in 2004 and 2005. The first was actually a business venture rather than a time-bound project. This was Umeme Jua, a Dutch-Tanzanian joint venture mentioned earlier and discussed in some detail in this section. The next projects to be implemented were funded by UNDP-GEF (started in 2004), UNEP-GEF and Sida (both started in 2005), and finally the Free Energy Foundation (FEF), which was piloted in Tanzania during 2004 to 2006 and then maintained thereafter. The Umeme Jua venture is discussed here in some depth as its activities reveal many of the subtleties and difficulties of the niche-building that occurred in Tanzania, and it articulated an expectation that became widely collectivised among actors in the niche. The other projects are not discussed in the same depth as they tended to use a similar approach to that of Umeme Jua. This is not to say that the Umeme Jua approach was imitated by these other projects. It is possible that this was the case but it is more likely that many of the actors designing the other projects were already forming expectations similar to the one Umeme Jua articulated. As these projects started their work, and the networks of actors began to enlarge and to integrate, they each generated their own learning and increasingly shared this through their formal and informal interactions. Over the period of about four years, from the beginning of the Umeme Jua venture to the implementation of the other projects, the solar home system (SHS) market in Tanzania evolved from one in which there was perhaps a trickle of activity to one in which there was explosive growth.

This section, therefore, attempts to understand the form the various interventions took and to explain how these interventions contributed to this rapidly growing market.

There may have been other projects implemented in this period, but they were small in comparison with those discussed below. The only other project of substantial size was one under the World Bank. However, this project – Tanzania Energy Development Access Project (TEDAP) – had not started at the time of the fieldwork, and so is not discussed here.

Umeme Jua

As implied in a brief description given in section 6.4.1, an important relationship developed between TaTEDO and the Dutch PV manufacturer Free Energy Europe (FEE) in the late 1990s after FEE sent a Dutch engineer – Marcel van der Maal – to work with TaTEDO while introducing FEE's amorphous modules to the Tanzanian market (van der Vleuten 2008). Frank van der Vleuten (Marketing Manager of FEE) was interested to see if the PV market could be developed in Tanzania, having already experienced success selling FEE modules in Kenya. Karlijn Arkesteijn joined van der Maal as an intern with TaTEDO in March 2000, also working in support of FEE's interest in developing a PV market in Tanzania (Arkesteijn 2009). One of her main contributions in this respect was the PV actor survey discussed in section 6.4.1. A combination of the relationship between FEE and TaTEDO, FEE's interest to develop a PV market in Tanzania, the market expectation partially supported and articulated by Arkesteijn's survey, and a Dutch Government goal of realising sustainable energy services in developing countries culminated in a FEE proposal to start a joint venture in Tanzania. The Dutch Ministry of Economic Affairs, through PSOM[65], was granting funding for joint ventures that sought to promote sustainable energy services in developing countries. FEE, Ameco Environmental Services (a Dutch consultancy), TaTEDO and Fredka International (a Tanzanian consultancy) started their joint venture – which they called Umeme Jua[66] – having secured funding from PSOM (Snel, van der Vleuten, Panjwani *et al*. 2006). In 2001, Jeroen van der Linden came to Tanzania to get Umeme Jua started and it began its operations in 2002 (van der Linden 2008). Although no breakdown of its capitalisation is available in the public domain, the combined finance initially invested in Tanzania by PSOM and Umeme Jua is given in a GEF

[65] PSOM has now become the Private Sector Investment Programme (PSI) but is still under the Ministry of Economic Affairs (see http://www.agentschapnl.nl/en/node/50050).
[66] The name is constructed from Swahili words for electricity (umeme) and sun (jua).

proposal (for a later project in Mwanza – more on this project below) as USD 630,000 (2003 dollars) (URT, UNDP and GEF 2003).

Umeme Jua had intended to apply the model of supply that FEE had successfully used in Kenya (Snel *et al*. 2006). That made use of Chloride Exide's[67] dealer network (van der Vleuten 2008). However, no such player existed in Tanzania and so Umeme Jua had to identify dealers individually in the regions in which they decided to operate – one reason for the EAA-TaTEDO-Ameco market surveys Umeme Jua commissioned, which we discussed in section 6.4.1 (van der Linden 2008; van der Vleuten 2008). Establishing these dealers was a slow process that, according to Arkesteijn, is unlikely to have occurred if Umeme Jua had not had significant funding from the Dutch government (Snel *et al*. 2006; Arkesteijn 2009). The density of dealers Umeme Jua attempted to achieve was driven by the goal of having the supply of products and services within 40 km of the end-user (Arkesteijn and Maaskant 2007a). In 2002, there were just two dealers in the network, but by the end of 2006 Umeme Jua had established 55 dealerships (claimed to be 20% of the company's potential dealer network) (*ibid*.).

Part of the reason this was a slow process is that it required training of the dealers (and technicians – Umeme Jua built a network of technicians to complement the dealer network). Initially, Umeme Jua used the kinds of training that had been developed by Hankins, TaTEDO and others: a long intensive course away from a participant's home or place of business. However, they changed the form of training over time, first by shortening it to five days and then eventually to a course that could be delivered in repeated visits to a shop, each instalment being conducted over a few hours (van der Linden 2008). This form accommodated the resource-constraints of retailers but required extensive travel on the part of the trainers and so was burdensome. But it generated other benefits. One of these was the building of trust between Umeme Jua and the retailer through the development of long-term relationships (Arkesteijn 2009). The trust issue was something that many interviewees, in addition to Arkesteijn, expressed as important in the Tanzanian market (e.g. Coutinho 2008; Musa 2008a; Schuurhuizen 2008; van der Vleuten 2008). Trust might also have been enhanced by Umeme Jua's practice of giving products on credit to the dealers, with the obvious benefit for Umeme

[67] Chloride Exide is a battery manufacturer in Kenya and has a network of dealers around the country.

Jua of getting their equipment into the shops for customers to see (Arkesteijn 2009). And one further incentive for dealers to stock and to sell Umeme Jua equipment was the offer of better terms on larger quantities of modules sold, supported by guarantees on delivery (van der Vleuten 2008). The guarantee on delivery was possible, of course, because FEE was the module manufacturer and so the supply was not subject to the vagaries of the international PV market.

Umeme Jua developed a number of marketing techniques at the same time as building the dealer and technician networks. In doing so, from about 2004, they worked closely with the Free Energy Foundation[68] (FEF), another Dutch entity, created by Nienke Stam and Frank van der Vleuten. These marketing techniques included demonstrating systems in prominent locations (such as markets in urban centres), advertising on radio (both national and local), and experimenting with micro-finance loans (van der Linden 2008; Arkesteijn and Maaskant 2007a; Arkesteijn 2009). Furthermore, when Arkesteijn became Umeme Jua's second managing director, they introduced standard PV systems to replace the previous bespoke designs. These simplified the process of explaining systems to customers in the shop, as well as simplifying training needs and supply requirements, thereby reducing costs (Arkesteijn 2009). When Umeme Jua demonstrated systems in prominent locations they did so together with aggressive marketing, such as is used by mobile phone companies. This involved music played over a sound system, giving away T-shirts and stickers, and so forth (van der Linden 2008; Arkesteijn 2009). Advertising on radio proved to be effective, particularly on local stations (Arkesteijn 2009). And, they targeted the migrant worker market identified in the EAA-TaTEDO-Ameco surveys, as well as exploiting opportunities created by increasing demand for TV[69] and the rise in mobile phone use (van der Linden 2008; van der Vleuten 2008; Arekesteijn 2009).

While these activities tended to be successful – in that they seemed to raise demand – the experiments with micro-finance were mixed (van der Linden 2008). Three models

[68] We will discuss FEF later but note here that it exploited the same Dutch Government development goal of realising sustainable energy services in developing countries, and made use of the funding to lower Umeme Jua's marketing costs (van der Vleuten 2008). However, it also worked with others in the market and made a specifically-designed brand available to all (a free brand) – Solar Now, or Solar Sasa as it became in Tanzania – together with marketing material such as flyers (Schuurhuizen 2008).

[69] Ramaprasad (2003:11, citing Onyango-Obbo 1996) reports that "[f]ollowing liberalization, in 1993, Tanzania allowed the emergence of private radio and television stations"; Smeltzer (1998:48n11) notes that, prior to this, members of the elite had access to TV equipment (VCRs, satellite dishes and TVs).

of financing for SHSs were tried by Umeme Jua (Flanagan 2005; van der Linden 2008; Arkesteijn 2009). Two of these were with micro-finance institutions (MFIs) – the Savings and Credit Cooperative Union League of Tanzania (SCCULT) and the Foundation for International Community Assistance (FINCA) Tanzania. The other was with a hire purchase company Tunakopesha, which deducts loan repayments directly from the salaries of its borrowers. The SCCULT model gave loans to members of a cooperative, while the FINCA mechanism used a lease model (Hansel 2006). No details were available concerning the experiment with SCCULT[70] but some were available for the experiments with FINCA and Tunakopesha.

The FINCA micro-financing of SHSs was unsuccessful for what Umeme Jua identified as two reasons (Umeme Jua 2007): one, the Bank of Tanzania MFI regulations require that a loan be supported with 120% collateral; and two, FINCA loan officers were familiar with lending money for income generating activities rather than products such as SHSs. Using a figure of USD 300 (2007 dollars)[71] for the price of the smallest PV system leased through the FINCA model, the collateral would have to be USD 360, which was difficult for many to provide. Moreover, FINCA could not lease a system for longer than six months. This meant the minimum monthly payment was USD 50, also difficult for many to afford.

In contrast, because they were not an MFI, Tunakopesha were not subject to the same banking regulations and could introduce a repayment schedule of between 3 to 36 months, meaning the same USD 300 system could be repaid at a rate less than USD 20 per month. The monthly interest for the 24-month schedule was 2.6% (ESDA 2007b:6). It was also the core business of Tunakopesha to give credit for products. According to Hansel (2006), Umeme Jua and Tunakopesha sold 210 systems through this pilot exercise, 75% of which were repaid over 24 months. This compared with FINCA's sales of 8 systems (Hansel 2006). During the first six months of 2007, Tunakopesha had sold more than 400 systems (ESDA 2007b:14). The hire purchase model was described by van der Linden (2008) as highly successful although Tunakopesha went on to become a competitor of Umeme Jua.

[70] However, Hansel (2006) reports that no systems were sold using the SCCULT model.
[71] The figure of USD 300 is taken from Umeme Jua's report on their experiences in the pilot programme (Umeme Jua 2007).

A method of financing not tried by Umeme Jua but attempted in a small project by FINCA was to use social capital as the basis for collateral. Felistas Coutinho, who had been the managing director of FINCA Tanzania, described this experiment as promising and was keen to develop it further after she started her own MFI Tujijenge Tanzania (Coutinho 2008). However, it could only be implemented through a donor as the method would fall foul of the Bank of Tanzania MFI regulations.

It took about three years before Umeme Jua began to see rapidly growing sales of systems. In 2002, they sold just 80 but this had risen to 3390 in 2006 (Arkesteijn and Maaskant 2007b). Although the numbers of systems were not given, by the middle of 2008, it was claimed that Umeme Jua had reached an annual turnover of about USD 1 million (Sawe 2008). Felten (2008b) reported that the average price per watt was just under USD 10 by this time. Therefore, using a crude calculation, we could estimate that Umeme Jua had sold about 100 kWp or approaching 5000 systems, using an average of 20 Wp per system (the average size of systems in Kenya by the mid 1990s, according to van der Plas and Hankins 1998).

UNDP-GEF Mwanza project

Four other large PV projects followed the Umeme Jua enterprise, although some of them were initiated earlier. Each of them bears remarkable similarities to the Umeme Jua approach and this could be seen as an indicator of the extent to which the PV actor-networks in Tanzania became far more integrated than they had been when Arkesteijn conducted her survey in 2000. The first of these was initiated around the late 1990s but was not implemented until 2004. It was a UNDP-GEF funded project in Mwanza Region (by Lake Victoria) and an instrument of MEM's energy policy (see, e.g., URT *et al*. 2003). The long delay it suffered before implementation afforded Umeme Jua, according to van der Linden, an opportunity to influence its final design during consultations with stakeholders in Tanzania (van der Linden 2008). It is certainly plausible that it was influenced in this way, particularly as the market survey discussed in section 6.4.1 that concluded with highly detailed prescriptions for developing the market in Mwanza Region was conducted by TaTEDO and Fredka, both shareholders in Umeme Jua (Snel *et al*. 2006). There was also influence during project implementation from other PV stakeholders in Tanzania. The Project Technical Committee included, in addition to UNDP, actors from the private sector, TASEA, Vocational Education Training Authority (VETA) and MEM; while the Steering Committee included some private sector representation, the Ministry of Finance, and (later) the Sida-MEM project (see below for more on this project) (Banks, Steel and Kibazohi 2007).

It concentrated on the Mwanza Region for the first three years, and was then replicated in other lake-zone regions during the final two years (Musa 2008b). While it appears it was strongly influenced by the Umeme Jua approach, it was not identical. For example, it donated some systems, which were placed in strategic locations as demonstrations. It also experimented with productive uses of PV such as powering barber shops, providing mobile phone charging services, and many others (Banks *et al*. 2007). Furthermore, it included a policy dimension, which involved the development of PV standards in collaboration with both the Tanzanian and Kenyan Bureaux of Standards, and sought to have taxes[72] on PV equipment reduced. Taxes were waived on PV modules in 2005 but this did not impact immediately on prices in the market, possibly because the cost of silicon was rising under increased international demand (de Villers 2007; Areksteijn 2009). The project experimented with micro-finance, just as Umeme Jua had done, but this was largely unsuccessful (Musa 2008a). In this, it tried to work with different actors to those Umeme Jua had engaged, but also found that MFIs were constrained by the Bank of Tanzania regulations, and other banks were not interested in financing SHSs. Nevertheless, the project was widely considered to be a success and the market for PV expanded significantly in Mwanza Region. Few numbers are available, but the mid-term review reported in Banks *et al*. (2007:28) states that sales of systems in the region were about 2800 for the period July 2005 to June 2006, almost twice the target figure for the whole project (which was to end in 2008). And annual sales in the lake zone had reached 8300 by April 2009 (Matimbwi 2011:13).

UNEP-GEF dissemination networks

In 2005, two large projects got underway, one funded by UNEP-GEF and the other by Sida. Both projects were initiated much earlier but suffered long delays. We discuss the UNEP-GEF project first (started in April 2005) before moving on to the Sida project

[72] The project worked together with TASEA on this and was successful in persuading the Government to remove all taxes on PV equipment. See section 6.5.1 for more on this.

below (started in May 2005) (de Villers 2007). The UNEP-GEF funded project was intended to develop dissemination networks across eastern Africa (centred on the successful Kenyan market from which lessons would be disseminated to the other countries[73] in the project) (ESDA 2004). In February 2002, the project held a stakeholder's workshop to elicit suggestions for the activities the project would implement. Along with others in the Tanzanian PV niche, Jeroen van der Linden (Managing Director of Umeme Jua at the time) was present (UNEP, EAA and MEM 2002). It is unclear whether van der Linden's presence was significant but it does establish that there was at least some kind of connection between the Umeme Jua team and the one managing the UNEP-GEF project in Tanzania (Energy for Sustainable Development Africa – ESDA, formerly EAA). The UNEP-GEF project certainly appears to have been influenced by Hankins' understanding of the success factors in Kenya, which were to target a cash-crop area (in this case, Iringa in Tanzania), set up a dealer network, train technicians, and raise awareness of PV among customers. In addition, the project tried to influence policy makers in respect of taxes on equipment and the development of PV technical standards (ESDA 2004).

While the project claimed a number of positive outcomes in Iringa Region and in the Tanzanian PV market (ESD 2007), there were also problems. First, the project start was delayed, partly through the UNEP system because of the need for clarification of project activities: it was the first time UNEP had implemented a PV commercial development project and so they had difficulty understanding it (de Villers 2007). But there were also difficulties with co-financing when Triodos Bank removed their support, originally budgeted to be USD 450,000 of USD 1.26 million in total (ESDA 2004). The removal of support was explained as a general change of policy within Triodos (de Villers 2007). Consequently, what was intended to be a 20-month project was, in practice, implemented over just twelve months.

A second problem was the relationship between the project and MEM. This is only touched upon in the evaluation report where it states that MEM were unhappy about ESDA managing both this and the Sida-MEM projects (see below), creating "some tensions with Government" (de Villers 2007:50). It is not possible to determine the

[73] The countries in the project were Kenya, Tanzania, Uganda, Ethiopia and Eritrea.

extent of these tensions but MEM appears not to have engaged deeply in the project (a situation similar to some of the other countries) despite a generally positive perspective on renewable energies. One hint from the evaluation report as to the reasons for the tensions lies in the recommendation that ministries be included in project steering committees (de Villers 2007:36). This *suggests* that the ministry was kept at arm's length from project implementation. This relationship problem with MEM could help explain why the project did not seem to have much impact at the policy level, but it is difficult to be certain about this.

Finally, there were problems with some of the project activities. In particular, there did not seem to be much impact on awareness-raising among customers, following a month-long campaign in Iringa Region. The reason for this low impact was attributed to the campaign occurring during December 2005, described as a "rainy and low-income season" (de Villers 2007:42). And little progress was made in experimenting with micro-finance. Some interest in this was apparent from the National Microfinance Bank (NMB) but no field experiments were attempted, only that NMB had developed a loan product for SHSs to be implemented through its 108 branches (ESDA 2007a:3). However, no further discussion of this product appears in the project documentation.

Sida-MEM project

Despite the difficulties experienced in the UNEP-GEF project, ESDA used much the same approach in the project they managed for Sida and MEM. This began just one month after the UNEP-GEF project, in May 2005 (de Villers 2007). Similarly to the UNEP-GEF project, this suffered long delays before implementation. The proposal went back and forth between the Sida offices in Sweden and Tanzania – with many adjustments – before it was accepted (Kårhammar 2008). This was, according to Kårhammar, because the project was a new way of working for Sida, which had been used to supporting large infrastructural projects rather than engaging in market development. The project concept was finally accepted after a change of personnel in Stockholm when some of the "old guard" moved on (Kårhammar 2008). Kårhammar remembers that the original idea came from Anne Kämp and was further developed by Lennart Bångens (who van der Linden says was a good friend). It took about seven years before it was implemented; the persistence to implement it sustained by it being one component of a much larger project that Sida was determined to pursue (Kårhammar 2008). It seems that there was an earlier intention for Sida to co-finance the UNDP-GEF project. This did not materialise but the Mwanza project manager was included in the Sida-MEM Steering Committee (Banks *et al*. 2007).

Despite the long process of developing a project proposal that was finally accepted by Sida (and MEM – Sida were keen that MEM "own" the project – Kårhammar 2008), the actual implementation was based on consultations between the incoming project manager, Jeff Felten (of ESDA who were managing the UNEP-GEF project simulatbeously), and local PV actors (Felten 2008a). So, once again, there was interaction and influence among those implementing projects in Tanzania – between Umeme Jua, UNDP-GEF and UNEP-GEF. Still, it was not identical to the other projects. It did share the multi-dimensional market development approach in general, and included a policy aspect similar to the UNDP-GEF intervention, as well as network building and marketing in line with the other projects. The difference was in the duration of its interventions. It targeted three regions initially (Tanga, Morogoro and Iringa) but then moved on to other areas quickly. The approach was to identify potential dealers (at least a few in each urban area), train them, conduct local marketing campaigns (similar to those used by mobile phone companies, as Umeme Jua was also doing), and then continue supporting the dealers with training for some time afterward. The network element of the project was achieved by providing funds to TASEA, which is discussed below. As with most of the other interventions, it appears that the project was successful. Indeed, as with the UNDP-GEF project, it surpassed its own targets in the first two years of operation. According to Felten's figures as of 2008, the Tanzanian PV market grew by 57% between 2006 and 2007 to an estimated 285 kWp. If the average size of a system were 20 Wp (as we have used above) then sales in 2007 could have approached about 14,000 modules. As a result of these larger quantities of imports, world reductions in cost, the removal of taxes and increasing competition in the market, the price per watt-peak of PV fell from USD 12.07 in 2006 to USD 9.85 in 2007, according to Felten's (2008b) figures.

Tanzania Solar Energy Association

Although created in 2000 and officially registered in 2001, the Tanzania Solar Energy Association (TASEA) is included in the discussion at this point as it did not receive any consistent funding until the Sida-MEM project was implemented (Felten 2008a; Kimambo 2008). Up to this point it had struggled to develop. TaTEDO hosted the organisation for several years and, from 2004, it made use of German student volunteers to help it function, as well as doing occasional consultancy work and training for the other projects in the country (Banks *et al*. 2007; Kimambo 2008; Magessa 2008; Sawe 2008). But one of the components of the Sida-MEM project was to develop the networks of PV actors and this was operationalised by funding TASEA (Felten 2008a). The funding paid the salary of the executive secretary, the development and running of a website, the production of an association magazine SunENERGY, and annual solar days (Felten 2008b; Magessa 2008). In the meantime, TASEA was to build up its membership with a view to becoming self-sustaining, partly through membership fees (Felten 2008a). This objective had not been achieved by the time of the field research but the membership was large and growing, standing at 236[74] at the time of writing.

However, at least a couple of contentious issues arose during this formative period. First, there was suspicion (and some resentment) among the members that the perceived close relationship with TaTEDO, while TASEA was being hosted at its offices in Dar es Salaam, meant that the association was not representing all PV stakeholders (Kimambo 2008). This suspicion began to ease once TASEA was able to move to its own offices. But further issues arose from the need for membership fees. In this case, there was disquiet that the redistribution of fees between the head office and the branches in Mwanza and Kilimanjaro was not entirely fair (Kimambo 2008; Magessa 2008). And there have been severe problems collecting fees. The Annual Report for 2009 states that only 12% of fees had been paid that year (TASEA 2009:4). It is not clear whether these tensions were resolved but the organisation continues to operate, although now under the new name of the Tanzania Renewable Energy Association (TAREA 2011:4).

[74] See http://www.tarea-tz.org/about-tarea/general-information/members. The breakdown is (TASEA 2009:3): 31 corporate members, 133 professional members, 32 associate members, 38 student members and 2 international members.

Free Energy Foundation

One other project is worth a short discussion. As mentioned above, the Free Energy Foundation (FEF) was created in the Netherlands by Nienke Stam and Frank van der Vleuten (of FEE) in 2003 to exploit a Dutch government policy of supporting the promotion of sustainable energy services in developing countries (van der Vleuten, 2008; Stapleton 2009:1). FEF was able to use this money to raise awareness of PV in Tanzania and so assist Umeme Jua (and others) in their marketing. FEF was not created to supply equipment; it operated by identifying entrepreneurial dealers, training them and connecting them to suppliers (Schuurhuizen 2008). A pilot phase took place in Tanzania between 2004 and 2005, during which FEF conducted actor surveys and developed the free brand[75] *Solar Sasa* in collaboration with Umeme Jua (ESDA 2007b). In 2007, the implementation phase got underway (Schuurhuizen 2008). FEF operated on a tight budget and so made use of Dutch volunteers, encouraged travel by public transport and expected retailers to contribute something to the copying of promotional material that used the Solar Sasa free brand (Schuurhuizen 2008). Umeme Jua made extensive use of this free advertising, and marketing, to the point where many actors in Tanzania associated Solar Sasa with Umeme Jua rather than something available to all. After FEF discovered this issue they and Umeme Jua attempted to make their operations more clearly separate (ESDA 2007b; Schuurhuizen 2008) but, at the time of the research, there was persistent disquiet expressed by some interviewees that FEF and Umeme Jua were the same entity.

It is straightforward to understand why this suspicion arose. Frank van der Vleuten was involved in both FEF and Umeme Jua, the organisations worked together to create the free brand, and together they further developed the market-building approach initiated by Umeme Jua. But, during 2006, the personnel in FEF changed. The "founders of the program left and were replaced by new professionals" (ESDA 2007b:4) and FEF began to target areas of the country, and other actors, not covered by Umeme Jua (Schuurhuizen 2008). However, they continued to use similar approaches to those developed with Umeme Jua: short courses (about two hours long); cost-sharing

[75] The concept of the free brand was twofold: it was open access; and it was meant to represent quality in technical, sales and support-services terms (ESDA 2007b). As such, a dealer and/or technician had to 'sign up' to this quality commitment before they could use the Solar Sasa promotional material and receive support from FEF.

production of promotional material; demonstrations of systems; and the building of dealer and associated technician networks (ESDA 2007b). They did not target policy makers or intend to influence policy in any way, and did not actively engage with NGOs; they focused entirely on entrepreneurs to try to help them develop business, sales and technical skills in PV (*ibid*.). While they learned a great deal about the constraints and practices of small business in the retail sector in Tanzania, and reflected this in the evolution of their interventions, their lack of engagement with other stakeholders generated some suspicion. One prominent actor interviewed during the research complained that FEF were being secretive; the interviewee asked rhetorically what FEF were doing and why they did not inform others about their activities.

Nevertheless, FEF built a network of dealers and technicians, additional to those of the other projects, and managed to establish enduring relationships with them (ESDA 2007b; Schuurhuizen 2008). Indeed, this building of trust was in some cases a problem because the dealers wanted to source their equipment directly from FEF rather than the suppliers in Dar es Salaam (Schuurhuizen 2008). This underlines the point made earlier about the importance of trust in the Tanzanian market.

Although it is difficult to attribute sales of modules directly to the efforts of FEF, the numbers of modules being sold through the dealers with whom they maintain relationships has increased. According to the Annual Report for 2009, about 12,000 sales passed through these 39 dealers, up from just under 7,000 in 2008 (REF 2010:13). The model of dealer and technician network building developed in Tanzania was seen as so successful that in 2007 FEF[76] began to roll it out to the other African countries in which it was operating (Stapleton 2009:1).

Summary

Each of the market development projects discussed above has contributed significantly to the growth of sales of PV systems in Tanzania since the early 2000s. The figures given by each of the projects are probably robust but there are no reliable figures for the years before these interventions occurred. Therefore, it is not possible to know with much certainty the total capacity of PV installed in the country. One estimate for 2008

[76] In 2008 FEF changed its name to the Rural Energy Foundation.

states that the capacity is likely to be at least 2.5 MWp – having increased by 300 kWp from the previous year – of which 1 MWp is estimated to consist of off-grid household systems and small scale commercial applications (Hankins, Saini and Kirai 2009:2). Between 2000 and 2007, the number of PV companies increased from less than 10 to about 20 (Magessa 2009:96), about five of which are major suppliers of equipment (Hankins *et al*. 2009). The number of dealers is difficult to discern but could be in the hundreds and the number of trained solar technicians is estimated to be more than 300 (Magessa 2009:87).

6.4.4 Analysis of the PV experiments

We can see the importance of articulation processes – both descriptive and connective – for niche and market development when we consider the activities of Umeme Jua. A large part of their effort was focused on connecting the demand and supply sides of the market, as well as connecting together the supply chain. But these efforts were guided by firmly held expectations, which they were able to envision because of the financial protection afforded by the Dutch Government's support. Articulating the supply chain involved years of work identifying entrepreneurial retailers, persuading them to adopt a PV expectation, and mutual first-order learning to envision and realise that expectation. In parallel with this work, Umeme Jua articulated a vision of SHSs to raise demand among customers and then connected that demand with the supply. Again, they were afforded important protection for these articulation processes by the Dutch Government's support for the Free Energy Foundation. Without such protection, it is unlikely they could have pursued the expectation, especially considering that it took until 2008 – over six years of effort – before their turnover reached USD 1 million. We do not know how much more money they spent in addition to the initial USD 630,000 invested in 2001/2002 (and so know whether they had achieved breakeven or profit) but, even so, it is clear that the venture was highly risky. No other private actor, financed privately, attempted to take on this risk; the other attempts to develop the market were large donor-funded projects.

The first of these to be implemented after Umeme Jua began their activities was the UNDP-GEF project. It is unclear the extent to which this project adopted Umeme Jua's expectation or the extent to which it was already held by those managing the project. It seems that van der Linden (and perhaps others) were concerned the project would try to introduce subsidies. These were not introduced, although a few donated demonstration systems were installed in strategic locations. The rest of the project, apart from its policy dimension, was similar to Umeme Jua's efforts. And, in effect, the other four components of the project performed similar articulation functions: to increase awareness of PV (articulate a vision for customers); to strengthen and support the private sector to deliver PV to rural areas (connect supply and demand); to explore financing (envision the finance dimensions of a PV expectation); and to disseminate experiences for replication (articulate a PV vision that can be collectivised). But the Umeme Jua team might have had more opportunities to influence the project as there is a strong chance that, through TASEA, they were either members or could communicate readily with members of the Project Technical Committee. Of course, it is also likely that the same mechanism would facilitate information flow in both directions so that the Umeme Jua team learned from the UNDP-GEF project.

The UNEP-GEF and Sida-MEM projects followed soon after, and were both managed by ESDA. There was a link between the UNEP-GEF project and Umeme Jua as early as 2002 when van der Linden joined the stakeholder workshop that was to determine the final design of the project. We cannot say who was more influenced in this meeting – van der Linden or the ESDA managers. But we do know that Hankins of ESDA already held a clear vision of PV market development gained from years of experience in the East African context. And, the project specifically set out to disseminate the Kenyan experience as a model for other countries. In any case, the activities the project implemented looked very much like Hankins' vision and *similar* to the one subsequently developed by Umeme Jua. They both created opportunities to foster articulation processes: build dealer and technician networks, and stimulate demand. The UNEP-GEF project was not particularly successful, partly because it was too ambitious and partly because it was implemented in less than 12 months. Evidence for this is provided by the Sida-MEM project, which used much the same approach under the same manager but was clearly a success. The main differences were that the Sida-MEM project was implemented over a much longer time period and in only one country; indeed, in only a few regions at a time.

By the end of 2004, Umeme Jua, FEF and UNDP-GEF were all active in Tanzania working to envision much the same expectation of a PV market with development co-benefits: that is, they were working towards ensuring that a market for PV would flourish and assuming this would bring development benefits in the form of electrical services to households. By the end of 2005, Umeme Jua (and perhaps FEF) began to experience some positive reinforcement that the expectation could be realised when the numbers of systems they sold jumped from 390 in the previous year to 1570. Likewise, the UNDP-GEF project surpassed its target for the entire programme in the 12 months between July 2005 and June 2006; and the Sida-MEM project recorded that the Tanzanian market was worth USD 2.2 million by the end of 2006 at a system price of USD 12 per Wp (Felten 2008b).

These were certainly encouraging results but they needed to be collectivised widely if actors were to maintain their search activities in the same direction and, therefore, envision the same expectation. SNM posits that broad networks of actors perform this function. We can see that the actor-networks were building across a number of regions of the country and they were linked formally through project committees as well as informally through interactions at the ‘centre’ in Dar es Salaam. TaTEDO, TASEA, Umeme Jua, ESDA, FEF, Sida, UNDP-GEF[77], MEM and the larger PV suppliers were all based in Dar es Salaam. They were all members of TASEA and, as we noted, there were interactions between many of them on project committees. And most were building their own networks across the country. It is straightforward to see that these connections would facilitate the flow of information. So, the networks could function in more ways than just the mechanistic connection of supply chains; they could also function as channels for collectivising expectations and visions by circulating information. Many of the interactions in the networks would need to be high-quality. We discussed this in respect of building trust between dealers and suppliers, but it is also likely to be the case on project committees and during other meetings where actors have a material interest in the outcomes. In other words, it was not just the supply chain that had become highly articulated; the niche network had become so too. Of course, not everyone in the niche was equally connected. Some might only interact with other niche actors during the annual solar days, for example, but niche development was substantial.

[77] The implementation unit for the UNDP-GEF project was based in Mwanza but both UNDP and GEF had main offices in Dar es Salaam.

With the niche network becoming broader and better inter-connected, and increasing numbers of actors working towards the same expectation, various institutions were developed and embedded more deeply and widely. This process of institutionalisation happened in many ways. Training was a significant part of this, both for technical and business skills. But it is important to note that the form this took evolved as a result of both experimentation (running training courses and evaluating them, such as TaTEDO did in their first large PV project) and long term interactions with those who were meant to benefit from the training (for example, repeated visits to retailers while trying to establish dealer networks, such as the work done by Umeme Jua and FEF). So there was a great deal of learning in this process. Obviously, those who were trained must have learned something but there was also learning on the part of the trainers, particularly in respect of the business practices in Tanzania and what the trainers thought needed to be developed in that area.

At a more formal level of institutions, there was (successful) effort to institutionalise PV training courses, achieved through VETA; taxes on PV equipment were waived after lobbying from TASEA, formally supported by UNDP-GEF; and PV standards were agreed but not gazetted (tax exemption and PV standards are discussed in section 6.5.1. It is obvious why exemption from taxes would be helpful to the PV market. However, it appears that PV prices did not fall immediately – perhaps because the cost of PV was rising in the international market. Nevertheless, according to one interviewee, the tax exemption at least sent a positive signal to the Tanzanian market that the Government was supportive of the technology (Arkesteijn 2009). The official institution by VETA of training courses could serve two purposes, both supportive of niche building and the potential for the niche to become a new regime or important part of an existing regime. First, official recognition confers some degree of legitimacy to the technology and the training courses. Second, it creates a strong link to the mainstream education system (the education regime), thereby broadening the network of actors with material interests in the success of the PV niche.

On the demand side of the market, there was the spreading (and complementary) practice of using rechargeable batteries for electricity in the household. This was an indicator used in the EAA-TaTEDO-Ameco market surveys precisely because of its alignment with the use of PV modules. Knowing the extent to which this practice was in place gave an indication of the demand for electrical services and could be exploited in marketing. Of course, once users began to charge their batteries using PV, they would be demonstrating its use or telling others about it. This word-of-mouth channel for information flow was found by FEF to be the most important when they were raising awareness of PV (ESDA 2007b). This relates, once again, to the issue of trust. Those customers using PV systems that continue to work are more likely to identify for others who are the trustworthy dealers and technicians.

Summary

The period following TaTEDO's entry into the Tanzanian PV niche was one in which we can see the importance for niche and market development of broad integrated networks of actors, a collectivised expectation envisioned through real-world experiments, and institutionalisation of socio-technical practices. Building such networks, generating and collectivising expectations and visions, and institutionalising new socio-technical practices are complex and risky processes. In Tanzania, these processes were assisted by the protection of donor-funded or supported projects that, fortuitously, were implemented almost contemporaneously. Each of the projects has its roots in either the early Tanzanian or, to some extent, Kenyan PV niches. Certainly, the early Tanzanian niche provided some protective space, albeit small and weak, in which to undertake the complex experiments of the 2000s. And elements of the learning gained in the Kenyan niche provided at least the skeleton of a model that could be nurtured in the Tanzanian context. Of course, other factors beyond the control of niche actors had important impacts. The cost of PV on the international market has fallen, although it has not decreased much since the beginning of the 2000s (and has at times increased); Tanzania's economy has been growing quite rapidly in recent years, although on per capita terms the country is still poor; and donors have become interested once again in the role of energy services in development, particularly low-carbon energy services. But these factors do not lead deterministically to a growing PV niche and market. Given the opportunity, it still took the efforts of many diverse actors focused on a collective expectation to generate the learning necessary to understand how to build both the niche and market for PV in Tanzania. However, despite the success that has been achieved so far, we are still talking about a niche; it is not yet a regime in Tanzania. There have been some long term interactions with actors from other regimes – finance and education, for example – and there have also been long-standing relationships between actors in the niche and those we might call policy regime actors. This is particularly evident in the relationships with some in MEM. The next section is the final substantive section of the chapter and discusses briefly some of the interactions that niche actors have had with the policy regime.

6.5 Interactions with the Policy Regime

This section sketches the interactions that niche actors have had with the policy regime. These were very different to the interactions between niche actors in Kenya and the policy regime there. For the most part, PV niche and policy regime actors have had a constructive, or at least peaceful relationship.

6.5.1 Policy, taxes and standards

Tanzania's 1992 energy policy (URT 1992) was updated in 2000, and finalised in 2003 with the Rural Energy Act passed in 2005 (URT 2005). The Rural Energy Agency (REA) was established late in 2007 and finished recruiting in early 2008. The REA was to implement part of the Power Sector Master Plan, supported by the World Bank, including a GEF-funded PV component of USD 6.5 million using smart subsidies (TEDAP 2007). The process of updating the policy was facilitated by funding from Sida and appears to have begun with the 1998 rural energy study. This fed into the more formal policy making process starting in 1999; a consultative activity that saw stakeholders from many sectors involved. The first draft was ready in 2000, following which there was further consultation and approval from the Cabinet before the final draft was accepted in 2003.

In 2004, TASEA submitted a proposal to the Ministry of Finance (MOF) requesting the Government waive duties and taxes on PV modules (Kimambo 2008; Magessa 2008). This was not accepted. But TASEA approached the Parliamentary Energy Committee and presented the proposal there. It received a favourable response but they suggested TASEA make a case for offsetting the lost revenue. UNDP-GEF also paid for the MPs to visit Kenya (Musa 2008a). After returning, they lobbied parliament and, together with TASEA's revised proposal (TASEA 2005) and the Rural Energy Act (URT 2005) in place, the tax-exemption was agreed. PV modules were now zero-rated on both duties and VAT. A year later, taxes were waived on all PV equipment.

In East Africa, the process of formulating PV standards, although an objective of TASEA since its inception, was initiated in Kenya. Most of the work drafting the standards was done there as well, as discussed in chapter 5 (see section 5.7.1). UNDP-GEF took up the issue in Tanzania and Rogath Kivaisi from the University of Dar es Salaam led the process of establishing approval. It took eleven stakeholder meetings to finalise approval in Tanzania but this was achieved with minor changes. At the time of the research, the standards had not been officially gazetted[78] because the Tanzania Bureau of Standards (TBS) did not have the necessary equipment (Hamid and Magessa 2009). Sida-MEM had taken on the issue of enforcing standards, and getting equipment for TBS (Felten 2008a).

6.5.2 Analysis of regime interactions

For the most part, interactions between actors in the PV niche and those in the policy and regime in Tanzania appear to have been constructive. The connections, of course, began at least in the mid 1980s with the creation of the Renewable Energy Section. But since Sawe left the ministry he has maintained his connections there, and other PV actors have been similarly careful to cultivate good relations with policy regime actors. This seems to have been reciprocated by the regime actors themselves: for example, there was a MEM representative at the Nairobi Regional Workshop in 1992; MEM had a seat as an observer on the first TASEA committee; and senior officials from MEM have attended the TASEA Solar Days. And MEM, as the executing agency for the UNDP-GEF and Sida-MEM projects, have some vested interest in the success of the projects.

So, there seems to be a shared expectation of PV in Tanzania that connects actors in the policy regime and those in the PV niche. This may be because the most recent energy policy process was a participatory one, funded by Sida. The workshop meetings and discussions may have helped to further collectivise expectations – perhaps to envision them – among both niche and regime actors. Only the UNEP-GEF project seems to

[78] That is, they had not been published in the official Government gazette and so were not considered to be in force.

have failed to maintain good relations. There is very little evidence about this but it would appear that the project managers did not follow protocols particularly closely and this may have looked disrespectful of MEM. This was not really an issue for that project's implementation, despite it having a policy dimension: the tax changes to be advocated were already in place by the time the project became fully active. But there may have been damaged relationships over the longer term between MEM and ESDA.

It is likely that the long-standing supportive attitude from the ministry, and the positive relationship with some of the key actors in the niche, was useful in regard to the removal of taxes but there may have been other factors involved. One of these could have been the drive to harmonise policies in East Africa. Although TASEA had submitted their proposal to MOF in 2004, taxes were not removed. It was not until after the visit to Kenya that there seemed to be a positive response. There was also the manner in which the case was made. This was something of a vision in that it provided quantified information about the benefits of tax exemption: there was no need to offset the lost revenue because there was almost no revenue anyway. Moreover, the development impacts would result in savings elsewhere: displaced kerosene, and more business opportunities generating wealth, development and revenue. In addition to the revenue case, the proposal deployed the argument that the new energy policy was explicit about the need to promote renewable energy use. And, the UNDP-GEF project may have started to lobby for tax exemption for PV. With MEM as the executing agency, there was likely pressure from within the policy regime to see tax removed.

On the issue of standards, this seems to have been driven primarily from Kenya. Private sector actors in Tanzania were also concerned that standards be introduced but not all niche actors share this expectation, even though they are to train border officials in their enforcement. Further, it is possible that TBS do not share the expectation either. We might anticipate some delay in implementing the standards under such conditions, but they had not been gazetted by the time of the research so we cannot analyse the implementation process here. Still, for the most part, the process of approving standards seems to have been quite straightforward in Tanzania.

6.6 Summary of the chapter

Having reviewed the PV niche dynamics over a period of about 30 years in Tanzania, we can begin to understand why it took much longer for a PV market to grow there than it did in Kenya. Although there was an early interest in the development potential of the technology, there was nothing that articulated a demand for PV systems, particularly for SHSs. The 1980s, in particular, were difficult in this respect. The only articulated demand was in the project market and so it was on this demand that private sector PV actors focused their attention. This was perfectly understandable. The country was, in general, poor and its infrastructure underdeveloped. There were few drivers of demand for electrical services in rural households. Only a few members of the elite had access to consumer products such as TVs, and there was no signal available until the early 1990s. With the cost of PV still high, it was highly unlikely that anyone would risk starting a business in PV for a private household market.

In the 1990s, a few actors did begin to investigate the possibility of using SHSs to provide electrical services in rural households, but this effort was inspired by the experiences in neighbouring Kenya. As such, these actors adopted an expectation that was not rooted in the Tanzanian context. They were driven primarily by the developmental benefits that PV could bring and saw the market as one way to achieve this; a subtle reorientation of the Kenyan expectation, which was about PV market development with development co-benefits. Nevertheless, the efforts in Tanzania did help to develop the beginnings of a PV niche in which a small number of actors became connected together and shared a similar expectation. Under the protection of a few donor-supported projects, they started to learn about how PV systems could work at the household level and trained others in the technical aspects of the technology. This built a small constituency of actors around PV and helped to indigenise some of the skills and knowledge required to support the technology.

By the end of the 1990s, both multilateral and bilateral donor interest in low-carbon development was rising and actors such as the GEF were looking to fund projects that implemented the low-carbon approach. Free Energy Europe, a module manufacturer, exploited this interest in its search to expand markets for its modules. And the donors themselves began designing projects to implement in Tanzania. The result was a flurry of PV projects that overlapped in temporal terms, and coincided with lower-cost PV modules and a growing Tanzanian economy. Furthermore, there were more drivers of the demand for electrical services. TVs were available and mobile phones were being adopted in large numbers. The actors who now entered the niche in Tanzania did so guided by an expectation of a PV market with development co-benefits. Through their activities on the ground, and protected from the full force of market selection pressures, they were able to envision this expectation in the Tanzanian context. As they built increasingly dense and well connected networks, the expectation of a PV market became more widely collectivised among actors in the country. With more actors working towards the same expectation, there was more focus on problem-solving to envision the market expectation. The rapid growth in PV sales by the mid 2000s further entrenched this expectation as dominant in the Tanzanian niche.

The next chapter brings together the explanations for the evolutions of both the Kenyan and Tanzanian PV niches, and their market development, to answer the research question driving this dissertation. It also draws some general lessons from the empirical material and the theoretical approach used to analyse this material.

7 Synthesis and Discussion of Case-Study Lessons

7.1 Introduction to the chapter

With the two case studies now in mind, we can consider the lessons that can be drawn from the research. We will do this in a number of stages. First, there is an empirical discussion that answers the research question. That is followed by a theoretical discussion that suggests how SNM may be enhanced. A number of issues are discussed including learning and expectations, and the need to address power, politics and risk. One area that remains unclear from the case studies is how to define the relevant regime. Some thoughts on this are expressed in the section on methodology after a description of a possible methodological contribution. Finally, the chapter ends with a discussion of what we might generalise from the case studies.

7.2 Empirical contribution: explaining the development of the PV niches in Kenya and Tanzania

This section presents – in three steps – answers to the research question. The first step gives a more general a-historical and short answer; the second gives a longer, historically sensitive version. The third step gives a synthesis of the case studies, examined systematically using the main SNM categories and is concerned primarily with the differences between the evolutions of the two PV niches.

7.2.1 Answering the research question

The research question driving this dissertation has been, 'Why are household photovoltaic systems being adopted at significantly different levels in Kenya and Tanzania?'

Of course, the answer to the question is not a simple one, partly because it must take into account a historical dimension. In this regard, the experiences of Kenya and Tanzania over the past 25 to 30 years have been significantly different, both in a general sense and in the particular sense of our focus of attention here. The answer is further complicated by the complexity of markets; something made more apparent perhaps because the context of our analysis is in developing countries. Nevertheless, having said this, we can attempt a short and a-historical answer. That is presented immediately below but, following this, I present a fuller analysis that tries to explain in SNM terms the evolution of the Kenyan and Tanzanian PV niches.

In short, the PV market emerged and grew quickly in Kenya because of the coincidence of a number of factors:

- favourable economic conditions
- significant demand for electricity
- the proximity of that demand to the Nairobi PV supply
- the 'density' of the demand
- opportunistic behaviour of entrepreneurs once the demand had been demonstrated

Once a market had emerged, further growth was largely sustained through the activities of the private sector. However, *niche development* was mainly stimulated through donor-supported interventions that enhanced actor-networks, institutionalised technical and business 'best' practices, and generated new expectations and learning. Not all these interventions were directly successful in market-growth terms, but they did enable experiments that would have been highly unlikely without donor-support. As a result, the Kenyan PV market has become increasingly well understood by the actors working within its highly interconnected niche, assisting indirectly further market growth, and has provided models that others have tried to translate to different contexts.

The delay, so to speak, in the emergence and growth of a household PV market in Tanzania can be attributed to a similar list of the factors stated above, except that they would be expressed in the opposite sense, and 'Dar es Salaam' would replace 'Nairobi'. While some of these factors – economic conditions and electricity demand – changed over time, the others were more difficult to address. The demand was widely dispersed, and certainly far from Dar es Salaam, making opportunistic entrepreneurial behaviour highly risky. It took concerted and sustained effort to find the demand, link it to the supply, and develop a business culture (albeit donor-supported) among selected actors who might exploit that connection. Again, it took donor support to absorb the risks that the local private sector was unlikely to bear; the risks associated with opening the market, learning and building capacity. And, again, niche development has been significant. Actor-networks have been extended and strengthened, technical and business ‘best’ practices have been institutionalised, and there has been significant generation of expectations and learning. And, as we have seen, the impact of these interventions on market-growth has been dramatic: an expansion in the market much faster than in Kenya, although the absolute numbers of systems and watts-peak are still somewhat below those of the Kenyan market.

With this short overview in mind, we will turn to a more historical discussion of the evolution of the Kenyan and Tanzanian PV niches. We have already seen in chapter 4 how PV was initially brought into the region as the result of an accommodation of expectations expressing different political agendas, the interests of the nascent PV industry (particularly in the US), and the understanding of household and community energy needs in developing countries. That discussion is not repeated here; instead, we begin with the emergence of the household PV market in Kenya and its initial growth. The discussion then continues by addressing the struggles and eventual emergence of the household market in Tanzania.

7.2.2 The evolution of the Kenyan and Tanzanian PV niches

A household market for PV emerged in Kenya due to the coincidence of chance, favourable location, conducive conditions and opportunistic action. It was a chance meeting between Burris and Hankins; one in which Burris saw an opportunity to get some work. His attempt to recruit Hankins to a PV expectation failed but it did connect him with the Karamugi school board. Following their visit to Burris’ home, the board were persuaded to adopt the expectation that PV could supply the school’s electrical services, at least on an experimental basis. The Karamugi installation then provided further envisioning and collectivising of the expectation among members of the school’s staff, persuading some of them to buy systems for their homes.

This readily-adopted expectation helped to stimulate second-order learning for both Burris and Hankins from which they formed a partially envisioned expectation of a market for household PV systems. In this part of Kenya, incomes from coffee production, in particular, were good and TVs were becoming available along with the TV signal, creating a demand for electricity. So, while much of the expectation formed by Burris and Hankins was unarticulated[79], they were able to begin detailing some important dimensions of it. They could articulate some characteristics of the demand, and they could identify roles for each of them in exploiting that demand: Burris would concentrate on the technology and business, and Hankins would concentrate on training.

Hankins then exploited his Peace Corps connection, and their institutional interest to support the supply of community services in rural areas through renewable energies, to secure resources for the three-schools project. That project was implemented in the same area as the Karamugi installation, a location only a few hours from Nairobi and relatively densely populated. The fact of population density was important because information about PV was easily circulated through personal networks. The proximity to Nairobi was important because it meant it was straightforward to supply equipment to the area.

Once the trained technicians from the three-schools project had been introduced to the Nairobi suppliers, the circulation of information about the market was considerably enhanced. Moreover, as a result of Burris' marketing strategy in which the technicians were also sales agents, the suppliers were increasingly able to exploit the marketing knowledge that these sales technicians were cultivating. So, information flow was readily facilitated: on the supply side, this enabled rapid learning about demand and the details of supplying to it; on the demand side, it enabled rapid learning about PV as a way to access electrical services and where to get the technology. The envisioning that was articulated by this learning helped to lower perceived risk on both sides of the market. For suppliers, demand was demonstrated and the characteristics of that demand were rapidly becoming clear. For customers, information about the use of the technology was becoming more readily available through personal contacts.

As the market in this first location became somewhat saturated, competition intensified. Total, who came into the market after Burris and Hankins had already started, were developing a dealer network around the country and appeared to be profiting as a result, and the other Nairobi companies began to seek ways to expand the reach of the market. The suppliers had already learned to do business in household systems and so were

[79] The use of 'unarticulated' refers to the expectation being unexpressed, either in spoken or written form.

innovating incrementally as they looked to market expansion. The development of dealer and agent networks, such as the one Total were exploiting, would have been easy to observe and, therefore, relatively easy to imitate. With the introduction of amorphous modules, a new model of delivering PV systems over the counter was introduced. This kind of product fitted well with the dealer network approach, and facilitated a brief but promising experiment with hire purchase. But the dominant user-expectation for PV was one in which ‘systems’ were built up piecemeal over time, and so most dealers accommodated this component-selling mode. The demand for electricity existed everywhere but most households had little prospect of connection to the grid. With the practice of battery based systems for electricity spreading, the use of PV could lessen the inconvenience of using battery charging stations while lowering the long-term cost of electricity. Altogether, therefore, PV was easily embedded into user-practices and preferences. Business culture was reasonably well developed and companies were able to market aggressively, based on demonstrated demand – essentially eliminating risk – and an already-accumulated knowledge of PV. In other words, the business of selling PV was becoming familiar; increasingly institutionalised into retail practices.

The situation in Tanzania was very different, even when there was some indication of a household market for PV. BP were installing some household systems but they appear to have failed to experience any second-order learning from which to form an expectation for a household PV market. Perhaps, and this can only be speculation, they *did* form such an expectation but it was one in which they articulated the demand as being confined to the most wealthy or one in which they could anticipate no profit. In general, consumer goods such as TVs[80] were either unavailable, in short supply, or very expensive. In any case, there was no TV signal, and lighting could be achieved using kerosene or other cheap techniques and technologies. In short, the expectation for PV in Tanzania, to the extent that one existed, was of no demand – certainly not any widespread demand – for household electrical services and so no demand for household PV systems.

[80] Ramaprasad (2003:11, citing Onyango-Obbo 1996) reports that “[f]ollowing liberalization, in 1993, Tanzania allowed the emergence of private radio and television stations”; Smeltzer (1998:48n11) notes that, prior to this, members of the elite had access to TV equipment (VCRs, satellite dishes and TVs).

Meanwhile, the extent to which there was a PV market of *some* kind in Tanzania, the actors involved had relatively easy access to it. The systems they were supplying were for large projects managed through Dar es Salaam, and funded by donors or other organisational actors. This enabled the suppliers to envision a straightforward expectation of PV in Tanzania, articulated through activities of generally low risk. With a simple business model envisioned there was nothing to stimulate any new second-order learning that might have led to a household PV expectation. Indeed, there is a strong indication in this that these actors were institutionally embedded in the 'project market'; a path dependence, guided by initial second-order learning of the existence of such a market and evolved through focused learning of a first-order quality to exploit it.

Any attempt to search for a household market would have been fraught with difficulty. The cash crop areas in Tanzania, where there may have been a chance of finding household demand, were far from Dar es Salaam; the infrastructure to reach them was weak; and the population was widely dispersed. Indeed, these conditions continue to prevail. We can see that even if a few entrepreneurs had been actively expressing expectations of household PV systems in areas where they may have been adopted, the geographical and infrastructural challenges alone may have prevented any progress. The low population density would likely have compounded the problem because it would have been difficult to collectivise the expectation among customers; contact through personal networks perhaps being infrequent, and contact with urban areas even less so.

The experiment at KARADEA serves to underline these points. While the project was important for other reasons, such as initiating an institutional trajectory in regard to training, it failed to catalyse any significant SHS market growth. Located in an area with a degree of cash crop economy, the project was able to articulate a household PV market to some extent. But it was difficult to collectivise any vision beyond the immediate area and those technicians who were trained there. Without any significant sales, it was also difficult to recruit to this vision actors in the distribution networks for goods such as electrical accessories. The supply chain, therefore, continued to consist of someone from the KARADEA Solar Training Facility (KSTF) travelling to Kampala, Nairobi or Dar es Salaam.

KSTF was one of a handful of projects implemented in Tanzania that were based on a PV household market expectation formed in Kenya. That expectation was partially envisioned in the Kenyan context and these other projects were intended to transfer that expectation-vision to Tanzania. However, the transfer proved to be problematic, and little development of the household market was apparent. Nevertheless, an increasing number of technicians was being trained and the previously isolated PV actors were beginning to form networks, albeit weak and fragmented. Still, a trickle of household systems was being installed each year; perhaps resulting from the activities of those such as KSTF and Ultimate Energy.

In Kenya, especially from the mid 1990s, important niche-development began to occur. Energy Alternatives Africa (EAA) were at the centre of much of this development work, exploiting the growing institutional interests in the development regime to fund renewable energy interventions. They successfully aligned these regime interests, the dominant market paradigm, and the interests of actors in the Kenyan PV niche to attract funds for a range of projects. The implementation of these then helped to connect actors in ways that encouraged deep interactions over sometimes long periods of time; developing technological artefacts, experimenting with finance, and testing new products. They also conducted a major market survey that helped to descriptively articulate the PV market in fine detail.

Altogether, these activities facilitated significant niche network growth and enhancement, the gathering and circulation of highly articulated market information, experiments with new expectations, links to complementary regime actors, and the building of technology management capacity among their own staff. And, they occasionally worked outside Kenya, most notably with KSTF where they developed the basic PV training course that helped to institutionalise technical practice in the region. Moreover, they worked to collectivise PV expectations and visions in the region and beyond through reports, articles, papers, seminars, workshops and, of course, training. Clearly, EAA were an important cosmopolitan actor in Kenya, and they had a significant influence elsewhere.

In Tanzania, unlike the Kenyan PV story, it is difficult to point to a defining moment that marked the beginning of rapid growth in the household market. However, there was a period during which a number of activities coincided, and conditions were perhaps more conducive than they had been earlier. The first of these activities was the implementation of the large Tanzania Traditional Energy Development and Environment Organization (TaTEDO) PV project at the end of the 1990s. Meanwhile, consumer electrical goods were becoming more widely available, and the 'middle class' was growing. While the TaTEDO project was still largely influenced by the expectation-vision formed in Kenya much earlier, it was more integrated than previous projects in Tanzania, and it covered much more territory and connected many more actors. It also provided a means through which Free Energy Europe (FEE) could begin to articulate, in the descriptive sense, the conditions in the Tanzanian PV market. And, by virtue of the extent of the project and the form of its activities, it enabled TaTEDO to emerge as the main cosmopolitan actor in the Tanzanian PV niche. Still, further envisioning of the expectation was focused on only a sub-section of supply-side actors; it failed to learn about the supply *chain* and to articulate market demand.

Despite these shortcomings, the project provided an opportunity for Arkesteijn to conduct research into the market and it was here that she formed a personal expectation that began to articulate the supply chain and demand aspects; an expectation largely shared by van der Vleuten at Free Energy Europe. As a module supplier, they already had formed an expectation of PV markets in Africa and were quite successful in Kenya. Through the Umeme Jua enterprise, FEE began to envision their expectation for Tanzania by combining knowledge from their own Kenya experience with that of a number of actors in both the Tanzanian and Kenyan niches. Moreover, they were able to align their business interests with those of the Dutch development agenda; securing funds to offset some of the risk of the Tanzanian venture.

The learning that ensued produced increasingly detailed articulations of the Tanzanian market along a number of dimensions of the overall expectation; occasionally stimulating shifts in the focus of these dimensions, with new first-order learning to envision them. The primary learning, however, was driven by the expectation that market development required connective articulation of supply and demand. That could best be achieved, according to the expectation held by Umeme Jua, by making use of existing distribution networks, working with 'proven' entrepreneurs, and understanding user buying-preferences. In the process, the PV niche was significantly enhanced.

Dealer and technician networks were developed and closely maintained, expanding the constituency of PV actors and collectivising an increasingly detailed vision of the private market diffusion of PV. And information flows through the market increased, raising awareness on the demand side and articulating problem-expectations and problem-visions regarding, for example, ‘weaknesses’ in business culture on the supply side.

It took some time for these activities to produce market results. Nevertheless, Umeme Jua persevered; a persistence motivated by a combination of sunk investments and, perhaps, the strongly held expectations of key actors in FEE and Umeme Jua. Eventually, volumes of modules began to flow, strengthening those expectations and providing a persuasive articulation that helped to collectivise them among other actors in the niche. That collectivisation is evident in the projects that followed, and each of these has seen similarly successful market growth in response to their interventions.

The experiences of the two niches have also been different with regard to interactions with their respective policy regimes. Important actors within the Ministry of Energy (MOE) in Kenya have been, at best, reluctant to adopt a positive expectation of PV; actors within the Ministry of Energy and Minerals (MEM) in Tanzania, by contrast, have long held at least a favourable expectation. Kenya’s MOE, it seems, were pressured into creating even a biomass department; Tanzania’s MEM quickly created a renewable energy section. Policy making in Kenya has been largely exclusive of the PV niche; in Tanzania, it was more of a participatory process. But neither was particularly influential on activities on the ground until very recently.

In Kenya, there has been the sudden adoption of a positive expectation of PV among some of the actors who had been hostile to the niche for so long; one tangible result of which is the large programme of taxpayer-funded PV systems for schools. It is difficult to explain the sudden adoption of this expectation without recognising the operation of power from higher levels within the policy regime. In Tanzania, MEM are coordinating the projects funded through UNDP-GEF and Sida; indeed, these projects are instruments of energy policy.

Paradoxically, perhaps, it seems that the Kenya Bureau of Standards have taken a keen interest in the quality of PV products in the market, while there are doubts whether the Tanzania Bureau of Standards (TBS) have any interest whatsoever. It is difficult to explain these differing responses satisfactorily, particularly as the evidence is weak. It could be that there was a coincidence of factors in Kenya that stimulated the adoption of some kind of standards-expectation: the imminent start of the PV Market Transformation Initiative (PVMTI), the PV Global Approval Program (PVGAP) process, and mounting evidence of poor quality components in the Kenyan market. In Tanzania, the alleged indifference of TBS could be that they were not driving the process – they were largely endorsing the standards developed in Kenya – and they could not see any significant quality issue in the Tanzanian market.

Finally, both niches have had similarly difficult experiences with finance regimes. Both have learned that the lending rules are disabling of micro-finance; a particularly painful experience for the Kenyan niche when it was trying to act within the constraints of two sets of misaligned lending institutions. Nevertheless, actors within both niches continue to hold positive expectations for micro-finance as a way to deepen access to PV and expand the market. The persistence of these expectations can perhaps be explained by their favoured place among development regime actors, the apparent success of hire purchase schemes, and the identification of the national bank finance rules as the constraint. In this sense, the dominant expectation that micro-finance will work has been envisioned with a reason why it has not yet worked. The implication is that the rules need to be changed; something we could call a problem-vision. In any case, connections between PV niche actors and some in the finance regimes continue; and, in the case of Tanzania, at least one of these is a strong connection in that Coutinho of Tujijenge is the treasurer of the Tanzania Solar Energy Association (TASEA).

7.2.3 A synthesis of the case studies in SNM terms

Having given a historical account of the evolution of the Kenyan and Tanzanian PV niches we can consider the main points to draw from the analysis in this dissertation, especially in terms of the differences between the two countries' PV histories. The discussion in this section does this by examining the two experiences explicitly and systematically from the perspective of SNM's main categories: expectations and visions, learning, actor-networks, and institutionalisation. The major line in this discussion argues that the two niches emerged with different dominant expectations, each of which had an important impact on the direction of learning pursued in the respective niche. The dominant overall expectation in Kenya has largely persisted; one of a household PV market with development co-benefits. In Tanzania, the initially dominant overall expectation gradually shifted during the late 1990s, converging with that held in the Kenyan niche. Initially, it was one of deepening and widening[81] rural access to electricity using PV but became one of a household PV market with development co-benefits. Even though the dominant expectations have converged in both niches, the visions in each case are different in certain respects, reflecting the specifics of each of their contexts. But the two niches differed in respect of the other categories of SNM as well, and these differences had impacts on niche and market development. We discuss each of the categories in turn but they are inter-related and so each discussion inevitably incorporates references to the others.

Expectations and visions

The household PV or solar home system (SHS) market expectation in Kenya, born from the Karamugi school installation, became dominant when the Nairobi PV suppliers adopted it following the USAID-supported project to install PV systems in three schools. The efforts of these private sector actors were then focused on increasing sales of PV systems to the household market, gradually envisioning the expectation with more detail and better understanding about how to achieve this. Hankins adopted much of this expectation but emphasised its development potential (i.e. deeper and wider rural access to electricity) and began to collectivise[82] this version of the expectation in Tanzania, working through EAA and KSTF. The Tanzanian effort then focused on devising PV systems that could reliably provide the expected development benefits to rural households. The market was one means to help deliver such systems but was not the focus of attention: the expectation was about deep and wide rural access to electricity from SHSs, whereas in Kenya the expectation was about sales of PV systems.

[81] Deepening access is used here to mean reaching more of the poor while widening access refers to reaching more users, whatever their income.
[82] As defined in chapter three, section 3.3.2, collectivisation refers to the process whereby actors adopt expectations and visions expressed by others.

The distinction between the two expectations is subtle but had important consequences for the directions of learning that were pursued in each niche, resulting in different outcomes. In Kenya, the SHS market grew quickly and excited international attention as a potential model of private sector led development. Up to the late 1990s, the market did not grow appreciably in Tanzania. However, the dominant expectation began to shift during the late 1990s and was in place by the early 2000s with the implementation of a number of temporally overlapping projects. TaTEDO began to include more private sector actors in their training courses, and to emphasise more strongly a business dimension in the training. Umeme Jua set out deliberately to develop a market to sell FEE PV modules. FEE and others influenced the expectation adopted by the UNDP-GEF and the Sida-MEM projects and so the expectation of a household PV market with development co-benefits (similar to the one in Kenya) then became dominant in Tanzania. Efforts were then focused on increasing sales of SHSs, as they were in Kenya, and the market certainly grew quickly soon after.

This is not to argue that the expectation of deeper rural access to electricity was dropped. Some actors maintained it – in both niches – and continue to do so. Indeed, it was important for recruiting resources from the development regime that helped the private sector to learn about other aspects of the market, even if the ‘development’ expectation itself has never been fully envisioned or realised. Some actors in each of the niches continue in their attempts to envision this expectation, most clearly evidenced by the interest in experimenting with micro-finance. And the limited experiments with micro-solar suggest that another expectation with a development emphasis could guide learning, although it has not been collectivised.

The argument is also not meant to suggest that adopting a particular expectation and then working to envision it is enough to realise the desired outcome. Other factors are certainly important. For example, the cost of PV, the extent to which the technology can deliver a desired or necessary service, its availability, its reliability, and so forth. The expectation is important because it guides search activities. These then reveal particular problems, and resources are brought to bear on solving those problems, but there is no guarantee that the problems will be overcome.

First and second-order learning

Guided by different expectations from the beginning, the learning that occurred in each niche was also different. But, in addition, there were differences in terms of the number and quality of opportunities to generate learning. Many projects were implemented in Kenya while, up to the late 1990s, few occurred in Tanzania. Furthermore, the actor-networks emerged quickly in Kenya and these helped to circulate lessons generated from donor-supported projects as well as from private sector activities. Actor-networks were small and fragmented in Tanzania until the end of the 1990s or beginning of the 2000s. This made it difficult to circulate any lessons – to the extent that any were generated. But we will discuss actor-networks in the next section. Here, we focus on the impact of learning, although this links to the actor-network discussion.

In Kenya, following the genesis of the household market expectation, Burris and others in the private sector, were focused on increasing PV sales. This focus drove first-order learning that resulted in describing more clearly market demand and connecting more strongly the supply chain to serve that demand; both aspects of what we have called articulation processes. But this first-order learning occurred because of an initial second-order learning experience that suggested such a demand existed and was worth further investigation – the expectation we discussed above. Furthermore, there were many opportunities for learning and the sharing of information about the market. There were the school installations – Karamugi and the subsequent USAID-supported project with three schools – which created the first opportunities to articulate the demand for SHSs. The project in the three schools also created an opportunity to learn about training. And the experiences in the field of the trained technicians, many of whom later worked for the Nairobi PV suppliers, helped to generate and circulate more information about market demand: both to articulate and collectivise an understanding of that demand.

Subsequent donor-supported projects created further opportunities for learning, some of which resulted in second-order lessons from which new expectations were articulated, at least along some dimensions of the socio-technical trajectory (as defined in section 3.3.1). One example of this was the Jua Tosha battery project. The concept for the battery arose from a finer articulation of user practices and requirements as understood by EAA through their market research and experience. The result was a new expectation of product functionality (deeper discharging than a standard vehicle battery) and probably had some impact on production process technologies and aspects of battery-manufacturer engineering practices. The project helped to envision the new expectation by creating first-order learning in the field, and to collectivise it among the other battery manufacturers who were able to observe the project and to read about it in the project report. As the Kenyan case study shows, this pattern of donor-supported projects, working with private sector actors, was repeated many times. It often generated second-order learning, articulating new expectations that were then refined by private sector actors through first-order learning in the market.

In Tanzania, the initial expectation was also created through a second-order learning experience but it was indirect or vicarious learning. That is, it did not come from articulating directly an experience in Tanzania; it came from articulating an experience in Kenya, albeit an articulation in which the emphasis shifted towards ‘development’ rather than business. The result of this was to focus learning on the user end of the market and to neglect the supply chain. So, there was first-order learning about training technicians in how to design and install SHSs, and training users in their operation. There was little systematic effort to learn about and develop – to articulate – the supply chain and, indeed, there was little involvement of private sector actors. The few private sector actors working in Tanzania were, in effect, operating in some isolation from each other and the broader niche, unable to create many opportunities for learning and unable to share much information. This is not to suggest that the learning that did occur was unimportant. It was incorporated into later learning as new actors entered the niche and new projects were implemented. It also attracted actors with resources and so helped *niche* development. However, it was incomplete in terms of *market* development.

As the actors in the Tanzanian niche began to align their search activities with a PV market expectation, they began to articulate the problems that needed solving in order to develop the market. There were differences in detail compared with the Kenyan niche but similarities in process. That is, donor-supported projects, working with private sector actors, created opportunities for learning. Some of that learning generated new expectations on dimensions of the socio-technical trajectory, and some generated first-order lessons to refine those expectations. The dealer and technician networks built through Umeme Jua's activities provide an example here. In some ways, these networks were the same as in Kenya and so could be seen as a model transferred from there by FEE. But the detail was different. The expectation of a dealer network (the same as in Kenya) guided learning activities but the vision was realised using independent retailers (rather than an existing dealer network as in Kenya). This required additional learning, new forms of training, long term engagement, the building of trust, and other activities recounted in the case study. The main point here is twofold: problem-solving was focused primarily on PV market development, not rural electricity access using PV; and solutions evolved through first and second-order learning in donor-supported market-experiments with private sector actors in the Tanzanian context.

So, not only was the learning in each niche guided by different expectations from the outset but also the number of learning opportunities was different. The Kenyan niche was afforded many opportunities for learning from the beginning and many of the lessons were available either in the public domain or circulated through the networks of actors that emerged rapidly after the USAID-supported schools project. In Tanzania, the niche had few opportunities to generate learning until much later. Any learning that did occur was not made public and was not circulated easily, at least in part because the actor-networks were small and fragmented. The situation began to change in Tanzania towards the end of the 1990s with the entry of TaTEDO into the niche and the creation of TASEA in 2000. Soon after, a range of actors converged on a similar expectation of market development, and the implementation of overlapping projects guided by this same expectation created many opportunities for learning. As these were donor-supported projects, many of the lessons they generated were in the public domain. Furthermore, the actor-networks had become much larger and more integrated providing a means by which information could circulate more easily.

Actor-networks

As mentioned in the preceding discussion, the actor-networks were different in the Kenyan and Tanzanian niches, and these differences had consequences for market development. In the Kenyan niche, there were already important networks to which Burris and Hankins were linked. Burris' connections were more important for developing the technical aspects of PV systems: he was active in the appropriate technology network, which helped him when he came to assemble BOS components locally, and he knew the Nairobi PV suppliers. Hankins, as a Peace Corps volunteer, had access to USAID and was able to use this connection to secure resources for the schools project. Following the schools project, the network established between Burris, Hankins, the Nairobi PV suppliers and the trained technicians proved to be effective in generating learning, and rapidly articulating and collectivising that learning. This rapid exchange of information was also facilitated by the concentration of activity in one region of the country near to Nairobi.

The actor-networks in the early Tanzanian niche, by contrast, were small and fragmented. To the extent that they existed at all, they were largely inactive. The building of networks in Tanzania began to improve as a result of the courses run by KSTF but there were no follow-on projects in which the network relations could be reinforced, enhanced or built. It was not until the creation of TASEA – born out of TaTEDO’s large PV project – that the actor-networks in Tanzania grew rapidly and began to link together the widely scattered elements of the niche. The subsequent projects further enriched these networks and provided lessons that could be circulated through them.

On the demand side of the market, there were differences too. As noted above, the Kenyan market was concentrated in one region – a relatively densely populated area where cash crop farming was widespread. This made for dense personal networks and the circulation of information about SHSs, as well as raising the chances of such systems being seen by others. The cash crop areas of Tanzania were not targeted by donor-supported projects or private sector actors, until the early 2000s when Umeme Jua began its activities. In any case, Tanzania is a much larger country than Kenya and its population is more widely dispersed. The word-of-mouth circulation of information about SHSs that happened in Kenya would be much slower in Tanzania, even if that information were available. This problem was overcome to some extent in Tanzania by setting up dealers across the country so that supply was no more than several kilometres from potential demand. Information was made available to this potential demand by demonstrating PV in public spaces across the country (e.g. on market days) and advertising on local radio stations.

So, networks of actors were important for a number of reasons, and the quality and form of the respective networks in Kenya and Tanzania had impacts on both niche and market development. But the networks were also important for spreading and institutionalising practices, as we discuss in the next section.

Institutionalisation

Finally, we turn to institutionalisation and the processes of structuring in our two case-study niches. Again, we can identify differences and discuss their impacts on niche and market evolution. The differences lie partly in the fact that each niche experienced different learning opportunities and that the quality and form of the actor-networks were different. In Kenya, there were many opportunities to generate learning about current practice, and to develop and spread new practices. In Tanzania, there were few opportunities to do this until the implementation of projects that got underway at the end of the 1990s.

During the second half of the 1980s, the emerging Kenyan niche was very active and well networked, as we have discussed. Many of the technicians working in the niche had been trained initially in the USAID-supported project and some had worked with Burris. The activities of the technicians in the field – installing systems, cold-calling potential customers, and so on – provided them with many opportunities to learn about the preferences and practices on the demand side of the market, and to refine the technical practices they had learned in their training. Not all of them maintained the technical 'best' practice, as we noted in the case study, such that some 'poor' technical practices emerged over time. And customers themselves were seen to employ a range of practices from good to bad when using their PV systems.

The understanding of poor practice on both supply and demand sides of the market contributed to the justification for a number of projects, with impacts on various dimensions of the socio-technical trajectory including product functionality, user preferences, regulations, and others. For example, the Jua Tosha battery project was in part an intervention that sought to replace the use of vehicle batteries (considered poor practice) with a battery better suited to the operating needs of PV systems. In time, this kind of battery became a popular product. Less successful were experiments to locally manufacture charge regulators and monitors, although the product concepts proved to be popular – it was just that Chinese firms were able to manufacture them with higher quality and lower prices than Kenyan firms. And a number of formal and informal institutions were introduced: the development by the Kenya Renewable Energy Association (KEREA) of a members' code of conduct; the writing of training manuals and a nationally-agreed PV training curriculum; and the agreement on PV standards, among others.

From the early 1990s, much of this institutionalising activity was coordinated through EAA, which became an important cosmopolitan actor in Kenya and throughout eastern Africa. They conducted and shared market research, developed project proposals, attracted resources for projects, connected to actors in complementary regimes (such as the finance regime), and worked with a large number of actors across the country. Without these efforts, it is difficult to see how the Kenyan PV niche would have developed beyond its initial market expansion activities in the late 1980s. However, during the mid 2000s, EAA became less prominent in this role, although Hankins was still an important actor in the PV niche. Instead, others began to take on elements of the cosmopolitan role in Kenya: KEREA, the Kenya Bureau of Standards and the Ministry of Energy being the most obvious.

In Tanzania, there was no clear cosmopolitan actor until KSTF began their training courses in 1993. Prior to this, there were few projects and there were certainly no actors coordinating efforts or even sharing information, except for a couple of reports from the MEM that only catalogued renewable energy installations in the country. From 1993, EAA were the main institutionalising actor in Tanzania. They worked mostly through KSTF but they also managed to implement a few training courses in other places during the 1990s. To this extent, they performed the role of cosmopolitan actor, albeit to a lesser extent than they managed in Kenya. However, TaTEDO emerged as Tanzania's main cosmopolitan actor from the end of the 1990s, having secured resources for a large PV project across three regions of the country. They hosted TASEA for several years, became partners in the joint venture Umeme Jua, and continued to implement projects in which PV was a central part. They also worked with others in the Tanzanian niche as well as with actors such as EAA in the Kenyan niche, connected to complementary regimes (such as the finance and education regimes), attracted resources, helped to generate and share information, and build networks. However, as with the Kenyan niche, the role of cosmopolitan actor in Tanzania has become distributed: TASEA, Umeme Jua, UNDP-GEF, Sida, MEM and the Free Energy Foundation have all contributed important institutionalising activities. As with the Kenyan niche, it is difficult to see how the Tanzanian niche would have developed without a cosmopolitan actor or actors, as there now seem to be.

Summary

The main argument presented in this section has been that the Kenyan and Tanzanian SHS niches developed initially along different socio-technical trajectories because they were guided by different expectations. In Kenya, the expectation was primarily about a market for PV modules; in Tanzania, the expectation was mainly about deep and wide access to electricity in rural areas by using PV systems. Learning was consequently guided in different directions in each niche. The Kenyan niche was successful at increasing sales of PV, while the Tanzanian niche was not. Once the dominant expectation in Tanzania changed to one similar to that in Kenya, learning became focused on developing the market. Actor-networks were important for gathering lessons from various locations and experiments, articulating problems and solutions, attracting resources, collectivising learning and institutionalising practices. In Tanzania, where actor-networks were initially small and fragmented, the niche struggled to achieve these things. As the Tanzanian actor-networks began to grow and integrate, the niche started to see these benefits. By the time of the fieldwork, both niches were well networked and both markets were highly active, with the Tanzanian market growing very quickly. However, neither could be said to have become a regime and neither appears to have solved the problems of deepening access to electricity in rural areas, an expectation that is still held by many actors in both niches.

7.3 Theoretical discussion

Strategic Niche Management clearly has some explanatory power in its analytical mode, and allows us to investigate important subtleties and interdependent processes that we might otherwise miss if we were to concentrate on, say, the price exchange of goods (although price is certainly important) when analysing technology adoption. But, as we discussed in chapter 2, while the framework recognises the importance of learning, it is frustratingly vague in its theorising of learning and its relationship with the other elements of the approach (that is, expectations, networks and institutionalisation). Our earlier discussion of learning theories presented some ideas that might connect SNM more fruitfully to the literature on learning. The assumption here, of course, is that if we have a more robust theory of learning in SNM then we will be able to better analyse niche dynamics, but also that we will be able to better design niche experiments to exploit learning opportunities when SNM is used as a policy tool. This section draws on the theory discussed in chapter 2, and insights from the cases, to attempt to suggest a way forward in theorising learning in SNM.

7.3.1 Learning, expectations and visions

Throughout the dissertation, we have assumed that expectations, visions, institutions, networks and technological artefacts can be conceived as expressions of learning. More directly, they are expressions of knowledge, itself an indicator that learning has occurred. We can see these as relatively stable outcomes – the sort of 'static' elements, or snapshots – of the dynamic element that is the process of learning. But this is not a one-way influence; it is not that a dynamic learning process occasionally spits out an expectation or institution indicator for us to observe. Learning is guided by expectations and visions, constrained or enabled by institutions, funded by actors with resources who are connected through networks, and materialised and inspired by technological artefacts. But the interdependent relationship on which we have focused is between learning, and expectations and visions. This is quite simply because these are cognitive processes and schemata, experienced and held by actors who have the agency to shape the learning, expectations and visions of other actors when attempting to realise their own objectives. So, we are saying that these are the fundamental processes and tools with which we, as individuals, can attempt to effect change: invite or reject actors to or from networks; prescribe new institutions; design new artefacts; and so on.

Based on this understanding, we attempted to clarify what SNM could mean by first and second-order learning, and expectations and visions. We began by using the ideas of Berkhout (2006:302) and Eames *et al*. (2006:361-362) to suggest separate definitions for expectations and visions, whereby expectations are characterised by expressing objectives or direction, and visions include the detail of how to achieve the objective.

These are slightly reworked versions of the definitions suggested by Berkhout and Eames *et al*. but they served to simplify our starting point for the connection between expectations and visions, and first and second-order learning. From this, we concluded that second-order learning results in a change of direction or objective: in other words, second-order learning generates a new expectation. Likewise, first-order learning results in a clearer understanding of how to move in the direction or achieve the objective set by the expectation: in other words, first-order learning generates the vision.

These ideas also fitted usefully with the notion of a socio-technical trajectory, as we mapped it out in chapter 2, based on the discussion of Sahal (1981:22), Dosi (1982:152-153), and Hoogma *et al*. (2002:19). This gave us the notion of expectation dimensions, each of which could be envisioned – the focus of first-order learning – at any one time and by different actors. So, for example, we might form an expectation of user-preferences that says users prefer portable PV systems, based on our knowledge that the users in question are nomadic. This might be partially envisioned as users prefer solar lanterns, or further envisioned as users prefer BP Tata lanterns because they have very bright lamps. But, in field trials of different kinds of portable PV system, we might find that users do not want portable lights, they want systems that will power radios. Here, our expectation of user-preferences has not changed but our vision of them has, so we have experienced first-order learning. Alternatively, we may find that users do not want portable systems at all, they want to be able to install them in their homes. Here, our expectation has changed; we have experienced second-order learning. We may not yet know exactly what kinds of fixed systems they prefer so we will have to engage in first-order learning to envision our expectation.

From this basic set of assumptions, we were able to examine in detail the provenance of expectations and visions as we saw them in operation in the cases, and to analyse their impacts on niche dynamics. Furthermore, we can begin to see how the heuristic ‘classification’ of expressions of knowledge developed in chapter 2, and reproduced in Table 7.1 together with examples from the cases, could be used to help us analyse the sources of learning, and why some ‘knowledge’ is more readily transferred than other ‘knowledge’; or, in the terms we discussed in chapter 2, how and why some knowledge is *translated* from one context to another more easily. This has important implications for what we can generalise from learning in one setting for application in another. And, it has implications for what can be readily collectivised and how.

For example, and with reference to Table 7.1, the codified knowledge expression of Burris' PV system design procedures can be explained or given as a set of instructions to others, assuming they understand the language in which the procedures are codified. This process of explanation or instruction is likely to be short, and the procedures hold regardless of location. Consequently, the translation of this knowledge from an actor in one location to an actor in another is relatively unproblematic, and so it has the potential to be easily collectivised. Likewise, customer views of field tested products can be largely expressed in linguistic form and can be communicated to others through explanation or discussion. The views might not be expressed precisely and others might disagree that they represent all views – so discussion becomes an important part of communication – but they can be readily translated from one actor to another and so collectivised. A more flexible kind of linguistic formulation to express knowledge can be illustrated with TaTEDO's diagnosis of the failure of their first round of training courses to catalyse any PV activity. Through interpretation of this first-round experience, TaTEDO created an expectation – not necessarily collectivised beyond TaTEDO – that future training courses would have a bigger impact in the market if they included those already active in PV. As the 'knowledge' expressed in this expectation developed from interpreting their experience, it could easily be inaccurate and therefore open to considerable change during further experience. Hence, its expression is flexible and the communication of such knowledge would more likely occur through discussion and description (and perhaps persuasion) than, for example, instruction. This kind of communication could slow down any collectivisation process – particularly if persuasion is needed – and there could be context-specific factors that would have impacts on what is relevant to new locations. That is, there might need to be a process of localising the knowledge – a translation process.

Table 7.1: Knowledge expressions together with examples from the case studies

Knowledge expression	Example	Learning	Communication	Case examples
Codified (agreed, established)	Mathematical propositions (rigid)	*First-order* Measuring, testing, verifying	Instruction, explanation	Bank lending rules Burris' design procedures
Articulate (established, interpreted)	Linguistic formulations (stable)	*First-order* Investigating, questioning, analysing	Explanation, discussion	Hankins' MSc research Customer views of field tested products
Explicit (interpreted, inferred)	Linguistic formulations (flexible)	*Second-order* Observing, trying, risking	Discussion, description	Changed trainee targets to PV-active in TATEDO courses
Manifest (inferred, intuited)	Performance (fluid)	*Second-order* Observing, experiencing	Description, demonstration	Blyth learning from Migai about micro-solar commercialisation UJ understanding of need to build trust

The last of the forms of expression in which knowledge is manifest in performance can be illustrated by Umeme Jua’s understanding of the need to be build trust among the dealers in their network. Here, the need to build trust can be easily expressed, although its relative importance compared with other elements of business culture might be more difficult to discern. Furthermore, understanding how to build the trust of business associates could be difficult to determine. There are likely to be many context and culturally specific behaviours that need to be inferred and intuited from observation and through experience. Once learned, even if they can be described, they are not necessarily transferable to different contexts. The knowledge that trust is needed can be transferred but the practice of building trust requires translation. The process of achieving such translation will be slow, and communicating such knowledge will need (repeated) description and demonstration, particularly for an actor new to the context. Therefore, collectivising such knowledge will be difficult.

The point here is not to define what knowledge is and is not, or to prescribe the learning theory that SNM should adopt. There is already a well articulated debate about tacit and explicit knowledge, and what can be transferred or not (Polanyi and Prosch 1975; Cook and Brown 1999; Tsoukas 2002). And the literature on learning theories is vast and diverse. Rather, the point is to suggest that SNM could benefit from a more theoretically-anchored understanding of learning, and the discussion here demonstrates one way that this could be done, incorporating what we know about socio-technological trajectories and linking to a clarified – or simplified – interpretation of the expectations literature.

7.3.2 Enhancements to the SNM framework

There are opportunities for the SNM framework to be enhanced if we consider some issues that were made more or less clear by the cases we have discussed. These include its struggle to understand or theorise about power and politics in niche dynamics and how these relate to similar dynamics at the level of the regime. This dissertation could, for the most part, only hint at such interactions, the clearest instances of them seen in the introduction of the institutional PV systems programme and the contest over the energy policy in Kenya. Certainly, competing visions were involved here, but there were other issues such as a historical dimension to the relationship between MOE and the renewable energies sector in general and legitimacy to formulate policy. Other examples were suggestive of politics, such as: the disagreements around PVMTI; the perception of the relationship between TaTEDO and TASEA, and that between Umeme Jua and the Free Energy Foundation. Unfortunately, there is not enough evidence available for us to discuss this in any depth here, and it was not given any treatment in the theory in chapter 2, so we can only note the problem and recognise that a possible way to begin addressing it is through the ideas discussed by Berkhout (2006), Eames *et al*. (2006) and Konrad (2006).

Risk is another area of the theory to consider. It was clear in the case studies that much of the activity of the private sector in both Kenya and Tanzania avoided risk. It was also clear that the various projects supported by donors reduced the risk to the private sector and enabled valuable learning to take place. Of course, that learning often helped to reduce risk by articulating more clearly certain aspects of the market and, therefore, this suggests a way to begin addressing this shortcoming in SNM. However, this is based on a simple understanding of risk as being inversely proportional to information. Others have argued persuasively that risk is a much more complex concept than this (Stirling 1999). Again, the notion of risk itself is not a central theme of this dissertation, even though it is clearly an important perception among private sector actors; perhaps especially so in the context of highly cash-constrained actors in developing countries. Therefore, as risk appears to offer explanatory power to account for the reluctance of actors to adopt new technologies or develop markets, it would seem to be an element that SNM needs to theorise more satisfactorily.

Finally, in terms of the theory of SNM, it is unclear how to explain the persistence of expectations in the face of negative learning, or the dropping of expectations despite positive learning. The first of these cases – the persistence of expectations – can be seen in the micro-finance example in both case studies. We have already discussed why this might be so but it is not clear whether SNM can explain this. The possibility we discussed in the case study of Tanzania in section 6.4.4 concerned the different experiences of the UNDP-GEF project, Umeme Jua, and Coutinho, now of Tujijenge. The notion we introduced here was of problem-expectations or problem-visions. These would be analogous to expectations and visions as we have defined them in this dissertation. That is, just as an expectation expresses the objective to be achieved, a problem-expectation expresses the problem to be solved. Similarly, a problem-vision expresses the problem to be solved together with the means to solve it, although the means may not be straightforward to realise. The idea in this is that if a problem can be more or less defined then the expectation may be more likely to persist. Conversely, if a problem is difficult to define then it is unlikely to receive much attention and few actors are likely to provide resources for it.

So, to continue the example of micro-finance in Tanzania, we can see that some actors believe micro-finance is the key to deepening access to PV among poorer groups but it has not yet worked in practice. The expectation continues to be held by these actors and they have a vague notion of why it has not worked so far: that, in rural areas, it is complicated to monitor payments, chase defaulters, and so on. This would be a problem-expectation, as the problem is identified but not the solution. For some, the reason that micro-finance has not worked is much clearer. Here, it is that the lending rules of the finance regime are disabling, with the implication that the solution would be to change the rules. So, this is much more like a problem-vision: the problem is identified and there is a possible solution, even though it would be difficult to realise.

7.4 Methodology and SNM

As discussed above in section 7.3.1, we borrowed ideas from Sahal (1981), Dosi (1982) and Hoogma *et al*. (2002) to develop a map, or tree diagram, of a socio-technical trajectory. We then used this, together with notions of expectations and visions, to develop an analogous idea of a socio-technical expectation trajectory. The initial tree diagram was used as part of the methodology for the research to achieve two objectives.

The first was to help identify when a development in the evolution of the case was indeed a change of trajectory. The point of this identification was to make use of the notion given in Geels and Raven (2006) that changes in trajectory are indicators of prior learning and, therefore, could be sites for deeper investigation. The second objective was to identify any 'gaps' in the coverage of the case material. This was done by cross-tabulating the elements of the trajectory against the various developments in the case history and checking cells where that development had seen a change to that element of the trajectory. Empty cells would then indicate that a particular 'front' of the trajectory had been missed in the data collection (see Table 8.1 in the next chapter for an example of the way it was used in this research). As far as I am aware, this is a methodological innovation and one that could be useful for systematic data collection in research that is based on socio-technical theories.

The remainder of this brief discussion of methodology and SNM expresses some thoughts about regime definition. A major part of the regime idea, it would seem, is to do with expectations: fundamentally, these guide behaviour and therefore influence investments and other decisions. If we consider each domain, as Geels posits them, being aligned then we could consider the regime to be about aligned expectations, *primarily*. This is in some part about shared expectations but there will also be expectations specific to each domain. The point is that they are mutually supportive – aligned. This ignores material objects completely in any explicit sense, although we might argue that the existence of the expectations depends on these material objects to some extent. So, in a weak way, perhaps, material objects are represented in those expectations. What may constitute the rural electrification regime in Kenya includes the expectations of policy regime actors, which are aligned with the expectations of development regime actors such as the World Bank, who lend for rural grid extensions, and so on. At the very least, such alignment of expectations among key regime actors could exclude niche actors and their expectations. There are echoes or power in this, harking back to the discussion earlier in the chapter.

However, this is not entirely satisfactory – we do need to consider actual material artefacts and the extent of their use, otherwise we are only talking about virtual regimes. Still, it would give us something with which to work when we are in a context of difficult-to-identify regimes. Of course, there are practical difficulties with this approach. Do we have enough knowledge of user expectations, for example, to be able to say with any confidence that they are aligned or otherwise with those of other actors?

An alternative view of the regime notion

If we can sensibly talk of an electricity regime in Kenya, for example, then it is a complicated one. It involves the grid, it involves the use of generators, it involves the use of dry cells, and it involves the use of battery based systems, some of which are charged using PV while others are charged using the grid or generators. So, we can say that the PV niche is interacting with some notion of an electricity regime, particularly if we consider this from the perspective of users. They employ different ways to access electrical services based on what is available and what they can afford. Each element of this could be viewed as a niche in its way but, together, they form a set of practices that perhaps can be seen as a regime.

It is interesting to note that, if we consider a regime to be something at the governmental level, the ‘usual’ notion of a regime is significantly misaligned with this user-centred view. At the governmental level, the electricity regime is about centralised generation and grid-based distribution. At the user level, the regime is a *de facto* one: a combination of different practices, but sometimes overlapping and interdependent. If we want to maintain that a regime is about a dominant technology, and its associated practices and rules, then it is difficult to find an electricity regime in Kenya. If we define a regime based on dominant practices at the level of society then we see that the electricity regime in Kenya is a rather dynamic combination of several kinds of practices and technologies, used contingently and opportunistically and with a considerable degree of inventiveness.

7.5 What can we generalise from the cases?

What emerges clearly from the two case studies is the interdependent relationship between all the elements of SNM and technological artefacts. The implication here is that learning processes *require* deep interactions with material artefacts and between people in a context that is meaningful to the actors; meaningful in the sense that the actors have material interests at stake, even if the risks are substantially reduced. But these interactions do not necessarily emerge spontaneously; ‘market forces’ will not always cause learning to occur, particularly where the risks are perceived to be high.

This was certainly the case in Tanzania before the large projects were implemented. Tanzania is a very large country and the market for PV consists of potential customers who are widely dispersed, and difficult to reach because of these vast distances and poor infrastructure, both physically and through the use of the media. In order to stimulate the learning necessary to articulate that market, the risk needed to be borne by an actor who was willing and able to lose. In the case of Tanzania, this was unlikely to be a private sector actor alone. Umeme Jua were able to act because they had substantial support from a donor and because they were directed by actors who held strong expectations of a PV market in the country.

In the case of Kenya, a similar risk issue was apparent. In the early part of the story of PV, no private actor apart from Burris was looking to develop a household market. This he began to do once demand had been demonstrated to him. In any case, he had little to risk: he was desperate, according to Hankins. It was only after the donor-supported intervention that other private sector actors became involved and then invested some of their highly constrained resources in developing the market. Likewise, during the 1990s, there was little risk-taking even when the market was apparent. It took donor-supported interventions to stimulate new learning that articulated the market in much more detail.

In both cases, the processes of learning were facilitated through projects working together with material artefacts and actors in networks, and in the market. This helped them to operate on *something* while trying to achieve a goal that was meaningful to them. The learning associated with these activities was then further disseminated through reports – formally – and through general discussions, observations, imitations, and so on – informally. Moreover, it is difficult to see that much of the learning would have been disseminated if it had occurred entirely within the private sector. The fact that donors were involved meant that there was a requirement for formal reporting. In addition, the learning was used by cosmopolitan actors in their institutionalising activities, thereby further influencing niche development and growth.

A significant outcome of all these projects has been the articulation of business models. In attempting to identify what we can generalise from the research then it is probably here we should focus. However, it is not so much in the models themselves as in the process for their development. Although, having said this, the model developed by Umeme Jua in Tanzania is in many ways based on a structural-functional view of the market that could perhaps be applicable in other contexts: supply must be brought as close as possible to demand, and demand must be raised; in tandem with this, there must be highly local technical support for the technology. Nevertheless, the methods of developing the models are perhaps what are most easily generalised. These began from some understanding of local conditions. There was then a period of accommodating to those conditions – making positive use of them – and then spending time and resources to learn, by implementing meaningful projects as we discussed above.

7.6 Summary of the chapter

In this chapter I have provided answers to the research question and have expressed these in three forms. One was a general a-historical answer; the second explained the evolution of the Kenyan and Tanzanian PV niches in chronological form; and the third abstracted the key factors that explain in SNM terms why the niches evolved as they did. The main argument in this explanation is that the evolutions of the two niches were driven by different dominant expectations initially but later the dominant expectation guiding activities in the Tanzanian niche converged on the one long-held in Kenya. The dominant expectation that was eventually shared across both niches focused learning on developing the respective markets. This learning was successful in expanding PV sales in both countries, although the visions realised in each case reflect context-specific details. The learning has not been successful in either country at deepening access to electricity, although this is an expectation held by some actors who continue to search for ways to envision and realise it.

In a section on theory, I offered further discussion of a way for SNM to theorise first and second-order learning, and expectations and visions. I also discussed areas where the theory could be enhanced or extended. It was clear from the analysis of the cases that power, politics and risk need greater thought in the SNM framework, and there are some difficulties in explaining the persistence of expectations in the face of negative outcomes or the dropping of expectations despite positive outcomes. The notion of a problem-expectation was discussed as a way forward in this respect.

In a brief discussion, I explained a possible methodological innovation developed during the research for this dissertation that could help to make data collection more systematic, where socio-technical theories form the basis for the research. And the methodological discussion continued with some thoughts on the difficulties of defining socio-technical regimes. This was found to be particularly challenging in the East African context when trying to identify an electricity regime.

Finally, the main point to generalise from the cases is the importance of articulation processes. The importance lies in both the descriptive and connective articulations that are generated, as well as in the way in which these processes unfold. That is, the evidence from the case studies suggests that learning – a process of articulation – about technology adoption is facilitated by the involvement of a range of interested actors. By ‘interested’ we mean those who have a material stake in the learning process and its outcome. In our cases, we investigated technology adoption through the market and so private actors are clearly interested stakeholders. However, learning takes place in some form of experiment and this is always to some extent risky. Some of these risks are too high for private sector actors to bear, particularly in the context of developing countries, and so here is a role that donors can play by providing resources for what SNM calls protection and protective spaces. We have seen these roles played out in our case studies where one of the main outcomes of benefit to private actors and the market diffusion of PV has been business models.

8 Summary and Recommendations

8.1 Introduction to the chapter

In chapter seven, I answered the research question about the differential levels of adoption of PV in Kenya and Tanzania, and was able to abstract some useful lessons about the explanatory power of the SNM framework. In doing so, I highlighted a number of potential contributions that the thesis could make. These are summarised below before I move on to some reflections on the methodology, and then to more general conclusions that arise from the focus of this dissertation. Finally, I make some recommendations, first for future research and, second, for policy.

8.2 Contributions of the dissertation

Theoretical and methodological contributions

There are potentially two main theoretical contributions made in the thesis. One is the connection of first and second-order learning to vision and expectation development respectively. The notion here is that second-order learning generates a new expectation and first-order learning envisions it. Within this view, an expectation acts as something of a ‘target’ to guide the direction of learning, and first-order learning provides ‘movement’ in that direction. We saw this depicted schematically in chapter 3, and it is repeated here in Figure 8.1.

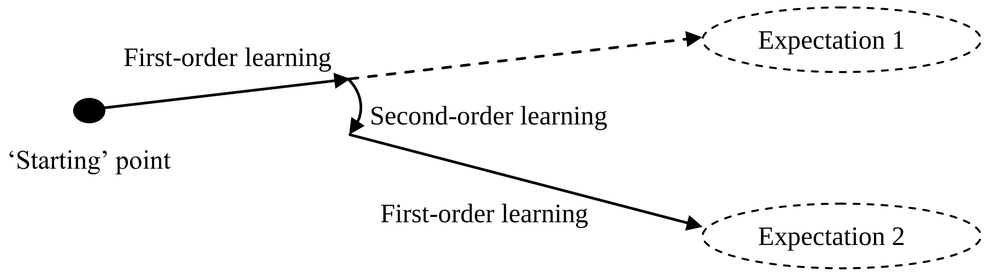

Figure 8.1: Schematic representation of first and second-order learning, and expectations and visions, whereby first-order learning details the vision

The other potential contribution is the notion of an expectation trajectory similar to a socio-technical trajectory. The idea here is that expectations have dimensions just as the more familiar notion of the socio-technical trajectory does.

A methodological aspect of the socio-technical trajectory dimensions lies in their use to check that we have captured trajectory developments in our field data. Table 8.1 gives a sample of how this is used, based on a few of the developments investigated in the Kenyan case. Where a development or event is thought to contribute in some way to a dimension of the socio-technical trajectory then the cell in the table is shaded. As can be seen, there is a conspicuous set of gaps where engineering contributions are missing. This reflects the lack of manufacturing in Kenya rather than missed data, but the point was to see the gaps and make sure that no developments were overlooked so that a more complete picture of the socio-technical trajectory of PV in Kenya could be drawn.

Empirical contribution

The dissertation outlines a nuanced explanation of the differential adoption rates of PV in Kenya and Tanzania. This gives more prominence to the role of donors in Kenya than is usually acknowledged, but less prominence than might be anticipated to the donors in Tanzania. The dissertation is also the first doctoral research, as far as I am aware, to compare the PV markets in Kenya and Tanzania; and is novel in that it uses strategic niche management as the theoretical framework to analyse, again at a doctoral level, technology adoption in developing countries.

Table 8.1: Major Developments in PV in Kenya and Socio-Technical Trajectory Dimensions

		Technological and Economic Trade-Offs							**User Needs**			**Institutions**		**Infrastructures**					
Year	**Event/Process**	Scientific Knowledge	Production Process Technologies	Skills	Procedures	Heuristics	Functionality	Aesthetics	Preferences	Practices	Requirements	Regulations	Government Policy	Supply	Maintenance	Training	Finance	Repair	Retail
1981	UN Conference on New and Renewable Sources of Energy	■								■		■	■	■					
1984	*Solar Shamba* started						■	■	■	■	■			■	■	■		■	■
1985	USAID/Peace Corps-funded school installations						■	■	■	■	■			■		■	■		■
1986	Cocktail party for solar technicians and suppliers													■					■
1989	aSi [a] modules introduced to Kenyan market	■	■				■	■	■	■	■			■					■
1992	Regional workshop held in Nairobi	■					■	■	■	■	■	■	■	■		■	■		■
1993	KSTF [b] built and runs first course	■					■	■	■	■	■	■	■	■	■	■		■	■
1998	PVMTI [c]											■	■	■			■		■
2001	Energy Policy process begins									■	■	■	■				■		
2006	Government-funded schools installations programme	■					■	■	■	■	■	■	■	■	■	■	■	■	■

Notes
a: Amorphous silicon.
b: KARADEA Solar Training Facility in north-western Tanzania, built as a regional solar training centre.
c: PV Market Transformation Initiative, a World Bank-GEF finance project

8.3 Reflections on the methodology

Strategic niche management is a complex theory. It has a number of conceptual pillars, each of which is complex in its own right. And this makes for a challenge in collecting and analysing the data required to do justice to the cases. Its complexity gives it explanatory power but it makes it difficult to research in practice; so its complexity is both a strength and a weakness. This is particularly challenging when it comes to writing interview questions. In order to gather data for all the elements of the theory, and to see how they change over time, one must ask a lot of questions. The generic interview questionnaire used for this research consisted of 29 main questions, a few of which were further divided. A number of interviewees were concerned, understandably, about how much time this would take. In the event, most of them gave generously of their time and provided material that was rich in detail. However, this wealth of material provided another challenge: how to work with all the information. Although, this is almost certainly an issue for any piece of qualitative research; part of the attraction as much as the challenge.

The process of analysis was also a major challenge. As outlined in chapter 3, for all the developments identified as somehow significant, I extracted information on each of the conceptual elements of SNM together with observations of the relationship to the elements of the multi-level framework. Once this was done, I integrated them into a single analysis. As one might imagine, this was very time consuming. The analysis it produced was at times illuminating but the two cases chosen, and the amount of information to process, made for a considerable amount of work. Having said this, I am not sure I would choose to do the analysis in any other way, mainly because it enabled such a deep understanding of the cases. But, it may have been better to bound the research a little more tightly, perhaps a shorter time period, for example.

8.4 General conclusions

One of the general conclusions to emerge from the research is that a socio-technical analysis reveals clearly the extent to which functioning markets are complex systems. It is unsurprising that markets are complex but, when they are functioning in some sense ‘efficiently’, we cannot readily see in what ways and to what extent this is so. By applying SNM – a theory developed in the context of largely functioning market systems – to cases where such conditions cannot be taken for granted, we are able to see that the theory itself is laden with assumptions regarding markets. At first sight, this could be seen as a problem: what sense is there in applying a theory that assumes conditions that are not present or are significantly missing? But, in the event, this worked to our advantage.

The benefit of using such an approach was that we were able to examine the extent to which PV market development in East Africa was a private sector endeavour. If we had focused, for example, on sales of PV modules then we would not have seen the efforts to articulate the niche, or the rest of the supporting structure of the market. By using the notion of socio-technical trajectories, we were guided to examine many more dimensions of market structure and functions. Moreover, because we were looking for *changes* in these trajectories, we were further guided to the sites of learning. This revealed the extent to which work had to be done to develop the markets in both countries and, especially in our case, the niches in both countries.

The Kenyan PV market ‘phenomenon’ has long been used to exemplify private sector led development. Donor influence has usually been downplayed, based on a lack of direct sales impact. But, as we have seen in the case study of the Kenyan PV *niche*, donor support has been important for other reasons. If it had been missing, it is highly likely that much of the second-order learning that led to new products and business models would not have occurred. The most obvious reason for this is risk-aversion on the part of the private sector; entirely understandable given the conditions of the Kenyan market and the often precarious income sources of customers. However, even where donor support did not enable new products or business models, it did enable the enhancement of niche networks. The private sector, for its part, often then did the first-order learning to develop coherent visions once new expectations had been formed; an important aspect of niche development and market growth.

In contrast to the sometimes trite characterisation of the Kenyan PV market as private sector led, the Tanzanian PV market could be seen as a purely donor led development, given the number of donor-funded projects in place at the same time. Once again, however, this is a simplistic reading of the situation. Indeed, the recent Tanzanian PV market story is actually rather complex. Donors were certainly involved in various ways for a long time but no significant market developed. Part of the explanation for this, of course, was the poor economic conditions. Nevertheless, there did not appear to be a significant market developing when the large TaTEDO project was underway at the end of the 1990s. Yet, within a couple of years, the market began to grow quickly. It was a private actor who finally began to find some measure of success there. But, a significant proportion of that actor's resources to develop the market came from a donor. And the other donors who are currently involved are not supplying equipment or subsidising directly; private actors are selling the technology.

So, in both cases, we see that the participation of donors *and* private sector actors was important. The balance of involvement may have been different between the two niches, and the kinds of interventions were certainly different: the Kenyan niche saw a number of experiments with products, while the Tanzanian niche is getting help with business and technical training. But the point is that it is difficult to see that either niche would have developed without the participation of both donors and private actors. The role of donors appears to have been, for the most part, to mitigate risk and so enable experimentation that led to second-order learning. The role of private actors appears then to have been mainly about adopting the expectations formed from experiments and developing the details of these – envisioning them – through practice. But, above all, whether the reality was as neat as this, there was considerable work done to develop the niches and markets. This is especially clear in the case of Tanzania, which only recently began to change from a 'socialist' to capitalist economy. However, even the Kenyan niche displayed some similarities, at least in terms of risk-aversion.

A number of important questions arise from the recognition that the market-based diffusion of PV technology in East Africa – especially Tanzania – has taken a major effort to establish, if indeed it is established. Clearly, market structures in Tanzania are not well developed and it takes time and resources to achieve their development. Five large donor-supported projects have been active in Tanzania for just one technology, and mostly concurrently (one of them – Free Energy Foundation – is not costing a great deal of money but its scope is large). To what extent would there need to be similar effort for other technologies? In what ways could such efforts imitate the approaches in these projects; in what ways would this not be possible? PV is not reaching the poor; how is all this effort contributing to poverty reduction? Fundamentally, is a market-based approach really going to work quickly enough for those who do not have access to modern energy, or even sufficient energy, at present?

To answers these questions we need, at least, to enhance our understanding of how new markets for technologies emerge in developing countries. The application of strategic niche management as an analytical tool could help in this regard, but there are aspects of it that could be refined in order to improve its analytical power. Even so, it has been developed specifically to address the emergence of new socio-technologies, whether analytically or prescriptively, and therefore focuses our attention on the micro-dynamics of building constituencies of support, learning in particular contexts, and institutionalising processes. Where technologies are new, or applied in novel ways or new settings, these micro-dynamics appear to be extremely important. Of course, focusing on technologies will not help us answer directly the other questions about access to energy services. But SNM offers us the possibility to include additional dimensions and to look to broader contextual factors than just the technical, by analysing the *socio*-technical. This potential could be important for linking together insights and research on the many dimensions of the energy and development problems faced in developing countries, particularly by the poor. These conclusions are about opening up the discussion concerning access to energy services in developing countries and so the recommendations given in the final section below reflect the need for deeper and broader questioning and experimentation in order to find solutions that work.

8.5 Recommendations

8.5.1 Further research

There are four clear recommendations to make for further research. As we discussed in the previous chapter, SNM could be enhanced through attention to the operation of power and politics in niche (and other) level development. A possible starting point for this agenda is with expectations and visions. In particular, the discussions in Berkhout (2006), Eames *et al*. (2006) and Konrad (2006), are all sensitive to this aspect of expectations.

The learning dimension of SNM could be strengthened by anchoring it more deeply in the learning literature. An attempt was made in this thesis to show how this might be achieved, although this was not entirely satisfactory. Still, my attempt did, I believe, bring greater clarity to what first and second-order learning means, and it points to some of the analytical benefits one can reap in terms of being able to design more effective experiments, and conduct more effective analyses, to maximise opportunities for learning.

The other potentially explanatory aspect, particularly as we have seen it in the case studies in this dissertation, is risk. If we begin from a simple understanding of risk being related to information or, more precisely, being inversely related to information then the link between learning and knowledge may be a useful starting point for incorporating risk into SNM. Of course, noting the recommendation above, this is assuming that SNM strengthens its theorising of learning.

There is wide scope to apply socio-technical theories in more empirical studies in developing countries, particularly in regard to the adoption of new technologies. This dissertation generated useful insights by doing this but could only do so with PV in two countries. It is therefore premature to draw strong conclusions. We could learn a great deal about the micro-dynamics of technology-adoption if we had studies of different technologies in different contexts.

8.5.2 Policy recommendations

In line with the theme of learning, these policy recommendations are focused on projects and how they could be designed and implemented to better foster learning in real-world experiments. The kinds of projects assumed here are those concerned with the introduction of technologies that could play a role in developing sustainable socio-technical practices, and where markets are seen as important mechanisms for disseminating such technologies. From the evidence and analysis presented in this dissertation, there is a clear role for donors in such projects to provide adequate protection against the full force of market selection pressures. It is under these conditions that actors can experiment to generate the learning needed for successful diffusion, adaptation and adoption of these technologies. But there are other aspects to projects that appear to be important. We should be clear about what a project is meant to achieve – the demonstration of a ready-made solution for others to imitate or experimentation to contribute understanding of what solutions could work. The motivation of project participants needs to be considered, as does the scope of projects. And, finally, as we have seen in the Tanzanian case in particular, the way in which projects relate to each other can have powerful impacts. Each of these aspects is elaborated below.

Role of donors

Many private sector actors, particularly small players in developing countries, cannot risk much of their capital to undertake experiments. However, there might be significant benefits if they were able to do this, for themselves and for wider society. Therefore, a substantial share of the risk inherent in experimentation could be borne by donors, who can justify their financial support in terms of these potential social benefits.

Another aspect of the risk issue is the stability and long term provision of support. If the support is unstable, intermittent or short term then it is more likely to increase risk than mitigate it. This is not to argue that support should be unconditional. There needs to be a way to maintain motivation in individual projects but the thematic, or overarching, support can be maintained so that there is confidence among stakeholders that it is worth them investing effort in particular technologies.

Projects as experiments

Projects can be seen as experiments that are implemented in order *primarily* to learn rather than to demonstrate particular solutions. In other words, projects could be recast as experiments to make this learning function clearer. As such, the measures of success of a project/experiment need to be considered carefully. For example, quantitative indicators can be useful but they can become the focus of evaluation. A range of qualitative *open questions* could help to identify more subtle but important impacts. This could also help to reduce the tendency to avoid discussing ‘failed’ projects. Such projects could be just as useful as ‘successful’ ones, perhaps more so. In essence, this is about the need to redefine success as having generated important lessons.

Motivation of project participants

In order for projects to generate useful learning, the participants must be motivated to solve real problems. That is, the problems the project or experiment explores need to be relevant to the actors involved and so should be defined by those actors. The motivation will be further enhanced if the participants have material interests in the outcomes; if the learning will have value for them. There is a clear link here with the issue of risk. While mitigating risk is important, particularly for private sector actors, the elimination of risk could be de-motivating. So, participants should be expected to invest some material resources in the project, partly to demonstrate to others their commitment but also to ensure that they have a stake in the outcomes.

The scope of projects

A clear lesson that emerges from the case studies is that learning is facilitated by deep interactions among a broad range of actors who can bring their problem-solving efforts to bear on the many dimensions of socio-technical trajectories in a range of contexts. This suggests that there needs to be experimentation on many of these dimensions simultaneously. However, it would be extremely difficult for a few actors to achieve this. To overcome this difficulty, either complex projects with a wide range of actors could be implemented or many simpler projects could be implemented simultaneously, each one operating on a selection of the dimensions of a socio-technical trajectory. Each approach will have its advantages and disadvantages. The point is to generate learning across multiple dimensions of a trajectory so that new socio-technical practices can emerge in a co-evolutionary process. The assumption here is that co-evolutionary learning will tend to produce mutually reinforcing practices that are sympathetic to their context, thereby increasing the chances of widespread adoption and sustainability.

Interactions with other projects

Following on from the previous recommendation, even complex projects or programmes of projects could be constrained in their learning, particularly if the funding is from a narrow range of sources. Moreover, if they are under the same management they will be dependent on the particular abilities of that management. As the Tanzanian case demonstrates, projects or programmes implemented from different perspectives, if encouraged to interact meaningfully over the long term, can generate learning that helps to achieve dramatic results. This requires some degree of coordination, of course, but not necessarily management. That is, the individual projects and programmes need to be able to communicate directly with each other as well as via a central actor.

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Appendix A

Generic Questionnaire

Introduction

These questions are intended to form the basic structure of the interview such that each question may lead to further questions, which would be for clarification and exploration of the main idea.

You are not obliged to answer any question you do not wish to answer and you are, of course, at liberty to end the interview at any time.

Before the interview begins, I shall ask you whether you are happy to:

- Have the interview recorded (I can provide a copy of the recording);
- Be cited by name and/or organisation/role, or prefer to remain anonymous.

Please check the recording at your earliest convenience and contact me with any corrections, or additional comments, as you feel are necessary or appropriate. We can agree a date beyond which I will assume no changes are necessary if I have not had any contact from you.

Questions

General overview

1. Please describe the process in general terms: how, when, why, and by whom, was it initiated; and how did it progress through to completion?
2. What was, or is, your role in the process, if you have not said so in answer to the previous question?

Before the process

3. What arguments were used to justify to actors that they should be part of the process, or that the process should be supported?
4. In your opinion, and as far as you can remember:
    a) Which arguments were persuasive, and why?
    b) Which arguments were NOT persuasive, and why?
5. What other processes or experiences were used to inform this process? In what ways did, or does, this process resemble and differ from these others, and why?
6. Who were, or are, the stakeholders involved in the process? Please give reasons why these particular stakeholders were, or are, involved.
7. What resources did each of these stakeholders bring to the process?

For this interview, I would like to define institutions as the following:

- *Policies (whether government, local and international organisations, or company);*
- *Laws (local and international);*
- *Regulations (local and international);*
- *Practices (technical, cultural and social);*

8. What do you consider to be the most important enabling and constraining institutions that existed before the process began? Please give reasons and examples.

During the process

9. In what ways, and to what extent, did the arguments change over the course of the process? Please give reasons and examples.
10. What new arguments were introduced, and why?
11. What existing arguments were dropped, or downplayed, and why?
12. If there were any changes to the assumptions on which the arguments were based, please explain what those changes were, how they occurred, and in what ways they affected subsequent discussions, arguments, and other actions.
13. What factors were, or are to be, measured, monitored, and assessed? Please give reasons for focusing on these factors.
14. What new institutions were introduced, or attempted, during the process? Please give reasons for the introduction of these new institutions.
    a) To what extent were these institutions created in response to the needs of the technology? Please give reasons and examples.
    b) To what extent was the technology affected by the needs of these new institutions? Please give reasons and examples.
15. What changes were there to the group of stakeholders during the process? Please give reasons for these changes.
16. In what ways did the provision of stakeholders' resources change during the process, and why did these changes take place?
17. In what ways was, or is, the network of stakeholders managed?
18. In what ways did the management of the network change during the process, and why?

After the process

19. In what ways, and to what extent, did the arguments succeed in influencing or generating action? Please give reasons and examples.
20. In what ways, and to what extent, did the arguments NOT succeed in influencing or generating action? Please give reasons and examples.
21. What impacts did, or will, the results of any monitoring or assessment have on subsequent action? Please give reasons for your answers.

22. In what ways did, or will, you (or others) disseminate this experience, and to whom? Please give reasons.
23. In what ways did the new institutions that were created affect, influence, or become, the mainstream? Please give reasons and examples.
24. If some, or all, of these new institutions did not affect the mainstream in some way, please explain what you consider to be the reasons.
25. What do you consider to be the most important enabling and constraining institutions at present? Please give reasons and examples.

Further reflections

26. What other factors were, or are, important drivers in favour, or against, the process? Please give reasons and examples.
27. What surprises, if any, were there for you in this experience? Please give reasons and examples.
28. What were the most important lessons learned during the process and in what ways did they challenge your assumptions? Please give reasons and examples.
29. If you were to go through the process again, what would you try to do differently? Please give reasons for your answers.

End of questions

Appendix B

Interviewees

First/Family Name		Role	Affiliation	Interviewed
Anil	Abdulla	Director	Telesales Solar	14-Jul-08
Bernard	Aduda	Professor and Chair of Physics, Leader of the Condensed Matter Group	Department of Physics - University of Nairobi	29-Feb-08
Paul	Amambia	Engineer	ESDA	02-Oct-07
Karlijn	Arkesteijn	Former Managing Director	Umeme Jua	09-Jan-09
Shem	Arungu-Olende	Former Coodinator for UN Conference on New and Renewable Sources of Energy	The African Academy of Sciences	28-Feb-08
Leo	Blyth	Engineer/Entrepreneur	Sunpak	18-Jul-08
Felistas	Coutinho	Executive Director	Tujijenge Afrika	24-Jun-08
Anne-Lie	Engvall	First Secretary, Programme Officer Infrastructure	Sida - Embassy of Sweden, Tanzania	11-Jun-08
Jeff	Felten	Senior Consultant	ESD Tanzania	23-May-08
Mark	Hankins	Former Managing Director	EAA	16-Nov-07
Frank	Jackson	Former Manager	KSTF	23-Sep-08
Mary	Kabatange	Former Country Liaison Officer	African Development Foundation	23-Jun-08
Ralph	Kårhammar	Formerly of Sida, Tanzania	World Bank	28-May-08
Oswald	Kasaizi	Former Executive Secretary	KARADEA	04-Jun-08
Savinus	Kessy	Programme Analyst, Energy and Environment	UNDP	18-Jun-08
Cuthbert	Kimambo	Former Chair	TASEA	05-Jun-08
Daniel	Kithokoi	Formerly of Solar Shamba	DAMUKI Enterprises Ltd.	11-Jul-08
Stephen	Kitutu	Managing Director	Tropical Solar Systems	20-Jun-08
Rogath	Kivaisi	Dean, School of Graduate Studies, Chair of TASEA	University of Dar es Salaam	26-Jun-08

First/Family Name		Role	Affiliation	Interviewed
Bughe	Kolowah	Former Technician	Ultimate Energy	16-Jun-08
Vincent	Loh	Chairman	KEREA - Kenya Renewable Energy Association	15-Nov-07
Gilbert	Maeda	Former Country Liaison Officer	African Development Foundation	22-Jun-08
Finias	Magessa	Secretary, TASEA Secretariat	TASEA	27-Jun-08
Hamissi	Mbaruku	Relationship Manager, MFI & SACCOS Department	National Microfinance Bank (Tanzania)	25-Jun-08
Hamisi	Mikate	Managing Director	Ensol Tanzania Limited	09-Jun-08
Dickson	Muchiri	Projects Manager	Solar World (EA) Ltd	07-Jul-08
Stephen	Mutimba	Managing Director	ESDA	29-Nov-07
Ngosi	Mwihava	Assistant Commissioner, Renewable Energy	Ministry of Energy and Minerals	25-Jun-08
Musa	Mzumbe	Former Manager, Project Coordinator	KSTF, UNDP-GEF Mwanza	06-Jun-08
Elias	Nchore	Owner	Enea Electronics and Arts	26-Jun-08
Ashington	Ngigi	Managing Director	Integral Advisory Ltd	21-Jul-08
Edward	Nyaga	Administrative Assistant	KEREA	15-Nov-07
Louis	Nyamwaya	Country Manager	Chloride Exide (Tanzania) Limited	18-Jun-08
Theodore	Ong'amo	Credit Control	KUSCCO Ltd.	18-Jul-08
Joseph	Onjala	Formerly of Ministry of Energy, Kenya	Institute for Development Studies - University of Nairobi	16-Jul-08
Charles	Onyango	Senior Inspector (Electrical)	Ministry of Energy, Kenya	13-Nov-07

First/Family Name		Role	Affiliation	Interviewed
Bernard	Osawa	Formerly of EAA	Lafarge East Africa (Bamburi Cement)	10-Jul-08
David	Otieno	Regional Energy Advisor, East Africa	GTZ	11-Dec-07
Charles	Rioba	Managing Director	Solar World (EA) Ltd.	02-Mar-08
Godfrey	Sanga	Manager Sustainable Energy	TaTEDO	17-Jun-08
Estomih	Sawe	Executive Director	TaTEDO	11-Jun-08
Ronald	Schuurhuizen	Regional Coordinator	Free Energy Foundation	29-Apr-08
Pepijn	Steemers	Managing Director	Umeme Jua Limited	19-Jun-08
Daniel	Theuri	Former Acting Head, Renewable Energy Department	Ministry of Energy, Kenya	08-Jul-08
Jeroen	van der Linden	Former Managing Director	Umeme Jua	16-Sep-08
Frank	van der Vleuten	Former Marketing Manager	Free Energy Europe	17-Sep-08
Henry	Watitwa	Chairman	KESTA - Kenya Solar Technician Association	11-Jul-08